
PLANS AND SPECIFICATIONS
PRIMARY ACTIVITY 1.0 - GROUP 1b
ON-SITE CONTAINMENT FACILITY
- FINAL -

Commencement Bay Nearshore/Tideflats Superfund Site
Operable Unit 02 - Asarco Tacoma Smelter Facility and Slag Peninsula
Ruston and Tacoma, Washington

Prepared for:

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SECTION II STANDARD SPECIFICATIONS

The 1998 Standard Specifications for Road, Bridge and Municipal Construction, prepared by the Washington State Department of Transportation and the American Public Works Association, Washington State Chapter, as modified by the 1998 APWA Amendments to Division One and the 1998 City of Tacoma Amendments, hereinafter called the Standard Specifications are the construction specifications for this project.

Standard Specifications are modified by Special Provisions as detailed in the following divisions. Division and subdivision numbers refer to corresponding numbers of the Standard Specifications.

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SPECIAL PROVISIONS
DIVISION 1
GENERAL REQUIREMENTS

1-01 DEFINITIONS AND TERMS

1-02.2(1) Associations and Miscellaneous - Add the following:

AMSL	Above mean sea level
CP&D	Comprehensive Plans and Documents
FTMS	Federal Test Method Standard
MDP	Master Development Plan
OCF	On-site Containment Facility

1-01.3 Definitions

Notice of Award - The written notice of the acceptance of the Bid from the Owner to the successful bidder.

Notice to Proceed - A written notice issued by the Owner to the Contractor (with a copy to Engineer) fixing the date on which the Contract Time will commence to run and on which Contractor shall start to perform Contractor's obligations under the Contract Document.

Bond - Bid, Performance and Payment Bonds and other instruments of surety, furnished by the Contractor and the Contractor's surety in accordance with the Contract Documents.

Change Order - A written order to the Contractor authorizing an addition, deletion or revision in the work within the general scope of the Contract Documents, or authorizing an adjustment in the Contract Price or Contract Time.

Work Directive Change - A written directive to Contractor issued on or after the effective date of the agreement and signed by the Owner and recommended by the Engineer, ordering an addition deletion or revision in the work, or responding to differing or unforeseen physical conditions under which the work is to be performed. A Work Directive Change may not change the Contract Price or the Contract Time, but is evidence that the parties expect that the change directed or documented by a Work Directive Change will be incorporated in a subsequently issued Change Order following negotiations by the parties as to its effect, if any on the Contract Price or Contract Time.

Written Amendment (Article 11) - A written amendment of the Contract Documents, signed by Owner and Contractor on or after the effective date of the Agreement and normally dealing with the non-engineering or nontechnical rather than strictly work related aspects of the Contract Documents.

Contracting Agency - Delete and replace with the following:

Owner, as defined below.

Engineer - Delete and replace with the following:

The Owner's representative who directly supervises the engineering and administers the Contract. For the purposes of this document, the Engineer shall mean Hydrometrics, Inc., 5219 North Shirley Street, Suite 100, Ruston, WA 98407 (253) 752-1740.

Owner - Add the following:

For the purposes of this document, the Owner shall mean ASARCO Incorporated, P. O. Box 1677, Tacoma, WA 98401.

Secretary, Secretary of Transportation - Substitute with the following:

All reference to the work "Secretary, Secretary of Transportation" shall refer to the Owner and its authorized representatives.

State - Add the following:

The terms Commission, Washington Transportation Commission, Department, Department of Transportation, State or State of Washington shall mean "Owner", except "State" shall be construed to mean State of Washington as indicated:

1. Whenever the words refer to Agencies or Department of the State of Washington other than the Washington State Department of Transportation, State sales tax, State employment agencies, State wage rates and State laws.
2. When referring to the Washington State Department of Transportation Laboratory manual.

1-02 BID PROCEDURES AND CONDITIONS

1-02.1 Prequalification of Bidders - Delete entire section.

1-02.2 Plans and Specifications - Delete and replace with the following:

Copies of the plans, specifications, bidding and contract documents may be obtained from Hydrometrics, Inc., 5219 North Shirley Street, Suite 100, Ruston, WA 98407, in accordance with conditions as set forth in the Notice to Bidders.

After award of the contract, one (1) set of plans and specifications will be provided to the Contractor at no charge. For each approved subcontractor or approved material

supplier, one set of plans and specifications will be furnished only upon request by the Contractor. Additional copies of the plans and specifications may be obtained on request by paying the actual cost of reproduction.

1-02.5 Proposal Forms - Delete the first paragraph.

1.02.12 Public Openings of Proposals - Delete

1-03 AWARD AND EXECUTION OF CONTRACT

1-03.1 Consideration of Bids - Add the following:

In addition to such other rights as may be reserved elsewhere in the Contract Documents, the Owner reserves the right to accept a Bid of the most favorable responsible Bidder, as determined by the Owner, to make arithmetical corrections in a Bid, to negotiate prices with the most favorable responsible Bidder, or to require the Work be done in another way if in the opinion of the Owner his best interests will be served.

1-03.2 Award of Contract - Amend second sentence as follows:

Delete "lowest responsible Bidder" and insert "most favorable responsive, responsible, qualified Bidder."

1-03.4 Contract Bond - Delete and replace with the following:

If the Owner has so requested prior to the signing of this Contract, the Contractor shall furnish bond covering the faithful performance of this Contract and the payment of all obligations arising thereunder, in such form as the Owner may prescribe and with such sureties as it may approve. If such bond was required by instructions given previous to the receipt of bids, the premium shall be paid by the Contractor; if subsequent thereto, it shall be paid by the Owner. If any change in work is authorized pursuant to the terms of this Contract, Contractor shall cooperate with Owner so as to ensure Owner's ability to secure and maintain the bonds for same.

1-04 SCOPE OF THE WORK

1-04.3 Add the following new section: General Notice

This remediation project is in response to the Consent Decree for Remedial Design and Remediation of the Tacoma Smelter Site issued by the United States Department of Justice, and lodged in U.S. District Court on June 24, 1996, and entered in U.S. District Court on January 3, 1997. It is intended to implement the remedial actions specifically required by that document and the work plans submitted by Asarco and approved by EPA. The Contractor shall be aware of and comply with all applicable Federal, State,

and local laws, especially those relating to hazardous waste handling and environmental protection.

1-04.3(1) Add the following new section - Contractor Submittals:

Submittals required of the Contractor are described in these Standard Specifications, the Special Provisions, and the Construction Quality Assurance Plan. The submittals may include, but are not limited to, materials specifications, testing results, proposed construction methods, equipment to be utilized, schedules, proposed subcontractors, materials samples, and other specified documentation.

For the purposes of this Contract, a minimum of two (2) complete sets, unless otherwise noted, shall be furnished to the Project Construction Manager/Supervising Engineer.

The Manager/Engineer will furnish a copy of the required submittals to EPA.

1-04.9 Use of Buildings or Structures - Add the following:

Property lines, limits of easements, and limits of construction permits are indicated as appropriate on the plans and it shall be the Contractor's responsibility to confine his construction activities within these limits, unless he makes arrangements for use of private property. Before using any private property adjoining the work, the Contractor shall file with the Engineer a written permission of the property owner, and upon vacating the premises the Contractor shall furnish the Engineer with a release from all damages, properly executed by the property owner.

The Contractor shall confine his equipment, storage of materials and operation of work to the limits indicated by law, ordinances, permits or direction of Engineer, and shall not unreasonably encumber the premises with his materials.

If the Contractor desires to use or permit any building or structure within the construction limits to remain during the performance of the contract, such use or existence will be at the discretion of the Engineer.

1-05 CONTROL OF WORK

1-05.7 Removal of Defective and Unauthorized Work - Delete.

1-05.12 Final Acceptance - Delete and replace with the following:

A Certificate of Completion for the project, submitted by the Engineer and approved by the Owner, shall constitute final acceptance of the work.

Final acceptance shall not constitute acceptance of any unauthorized or defective work or material, nor shall progress estimates be construed as acceptance of any work under this contract. The Owner shall not be barred from requiring the Contractor to remove,

replace, repair, or dispose of any unauthorized or defective work or from recovering damages for any such work or material.

Projects will generally be accepted in respect to construction at such time as they are entirely completed. However, on a project consisting of several separate entities, the Engineer may not accept any of these separate sections if the Engineer so elects.

1-05.14 Cooperation with Other Contractors - Add the following:

The Contractor shall conduct the work so as to cause a minimum of interference with the Owner's operations. Where interference with the Owner's operations becomes absolutely necessary, permission shall be requested by the Contractor not less than seventy-two (72) hours in advance.

When other Contractors or the Owner's forces are working on the job on the immediate premises, the Contractor agrees to so schedule the Contractor's work as not to make it necessary for the Contractor to cut into or otherwise alter any work that has been completed by such other persons. If the Contractor fails to do so, then the Contractor shall replace or repair the damaged work at Contractor's own expense and in a manner satisfactory to the Owner.

If any part of the Contractor's work depends for proper execution or results upon the work of any other person, the Contractor shall inspect and promptly report to the Owner any defects in such work that render it unsuitable for such proper execution and results. Contractor's failure to so inspect and report shall constitute an acceptance of such other work as fit and proper for the reception of Contractor's work, except as to defects which may develop in such other work after the execution of Contractor's work.

1-05.15 Method of Serving Notices - Delete this section.

1-05.16 Add the following new section: Water and Power (APWA only)

The Owner will not supply electricity, water, light, power, steam, compressed air or other utilities required for construction purposes unless specifically so provided in the Contract. Where such items are not supplied by the Owner they shall be furnished by the Contractor, and the Contractor shall, in either case, be required to obtain and pay for required permits and make the necessary connections, provide approved shut-off and safety devices and furnish and install all temporary lines required to bring them to the point of use.

Unless otherwise specified, all materials incorporated in the permanent work shall be new and both workmanship and materials shall be of the best quality. The Contractor shall, if required, furnish satisfactory evidence as to the kind and quality of materials.

The Contractor shall construct and maintain all necessary temporary facilities for the completion of the work. Upon completion of the work all such facilities shall, unless the Owner shall otherwise direct, be removed from the premises and the site cleared.

1-06 CONTROL OF MATERIAL

1-06.2(2) B Financial Incentive - Delete this section.

1-07 LEGAL RELATIONS AND RESPONSIBILITIES TO THE PUBLIC

1-07.14 Responsibility for Damage - Add the following:

The Contractor shall be responsible, and reimburse the Owner, for any loss or expense to the Owner arising from damage to the work or other property of the Owner caused by the wrongful act or neglect of the Contractor, any Subcontractor or of the employees of the Contractor or any Subcontractor. Where such damage includes damage to the work it shall be repaired at the expense of the Contractor.

The Owner shall be responsible for all damage to the work, including all materials and equipment owned by the Owner on or about the premises intended for permanent use in the project or incidental to the construction thereof and included in the total cost of the work except when the same are proximately caused by any act, omission or negligence of the Contractor, its Subcontractor(s) or their agents, employees or representatives.

The Owner may during the process of the work, maintain and pay for property insurance to cover the work during construction with such deductible as it may at its sole discretion choose or Owner may at its sole option completely self-insure same.

If the Contractor desires any other insurance, beyond that provided by Owner, to protect Contractor's temporary structures, materials, hand tools, machinery and equipment he may obtain and pay for same.

1-07.17 Utilities and Similar Facilities - Add the following:

The existence and approximate location of underground utilities or similar facilities will be indicated in the plans insofar as it is possible to do so. The existence and approximate locations will be determined by a search of available records; however, additional utilities may be encountered and the locations of the utilities indicated therein may vary from the actual locations of the utilities as indicated. The Contractor shall take the necessary precautionary measures to protect the existing utilities and structures indicated and any of the utilities or structures which may be encountered at the site during construction. Failure of the Owner to show the existence of subsurface objects or facilities on the plans shall not relieve the Contractor from the responsibility to make an independent surface check of the project site, nor relieve the Contractor from all liability for damages resulting from the Contractor's operations.

The utilities in Pierce County work together in a Council to help prevent accidents and damages to underground facilities. One telephone call to 1-800-424-5555, 48 hours prior to digging (excluding weekends and holidays) will relay a message to these utilities, as necessary. These agencies will give assistance in the location of the various utilities, but such assistance shall not relieve the Contractor from the responsibility for damage incurred, except where the installations are not located as closely as is normally possible with an electronic pipe locator or meet the additional exception criteria listed herein.

Existing underground utilities, whether public or private, which are damaged by the Contractor, will be repaired by the utility owner. The Contractor shall be liable for all costs resulting from the damage to a utility if:

1. The utility system is in a standard location adopted by the local jurisdiction, or is indicated in the Plans, and the actual location of any portion of the utility is within 24 inches horizontally of the standard location, or the location indicated on the Plans, or
2. The utility has field located and marked its facilities and the actual location of any portion of the utility is within 24 inches horizontally of said location mark, or
3. The utility system is visible or has become visible or can be reasonably assumed to exist at the location due to visible evidence prior to the damage, or
4. The Contractor has failed to provide the required notification to the utility owner of the utility that has been damaged.

The depth of the utility, if indicated, is for the Contractor's convenience only, and the Contractor's responsibility for damage as specified above shall not be altered due to the actual depth being different or other than that indicated on the plans.

The Contractor shall notify the proper utility immediately upon break or damage to any utility line or appurtenance, or the interruption of their service. He shall notify the proper utility when his operations may affect the service or cause damage to the utility involved.

Any loss of time suffered by the Contractor due to delay and removal or relocation of any utility or other facility by others may be adjusted in accordance with Section 1-08.8 permitting extensions of time.

1-07.18 Public Liability and Property Damage Insurance - Delete.

1-07.25 Opening of Sections to Traffic - Add the following:

If such prior use increases the cost of or delays the work, the Contractor shall be entitled to extra compensation in reimbursement thereof, or extension of time equal to the delay

or both, as the parties may agree upon, and failing agreement the dispute shall be determined by arbitration.

1-07.28 Add the following new section: Protection of the Environment

1-07.28(1) General

There is a possibility of elevated concentrations of metals in the off-site and on-site soil materials. The following provisions and those found elsewhere in these Specifications shall be strictly adhered to. The Contractor shall fully cooperate with the Owner, Engineer, and regulatory personnel to assure that all applicable environmental protection and safety requirements are met. Unless specifically provided for otherwise, such activities shall be considered incidental to the work and no separate payment shall be made.

1-07.28(2) Environmental Pollution

The Contractor shall maintain all work areas within and outside the project boundaries free from environmental pollution which would be in violation to any federal, state, or local regulations.

1-07.28(3) Protection of Waterways

The Contractor shall observe the rules and regulations of the State of Washington and agencies of the United States Government prohibiting the pollution of stream or river waters by the dumping of any refuse, rubbish, or debris therein.

1-07.28(4) Protection of Air Quality

The Contractor shall not discharge smoke, dust or other contaminants into the atmosphere that violate the regulations of any legally constituted authority.

The Contractor shall furnish all labor, equipment, and means required and shall carry out effective measures wherever and as often as necessary in the opinion of the Engineer to prevent his operation from producing dust in amounts damaging to property, cultivated vegetation, or domestic animals, or causing a nuisance to persons living in or occupying buildings in the vicinity.

The Contractor shall comply with specific requirements of air quality control laws.

The Contractor shall be responsible for any damage resulting from any dust originating from his operations.

The dust abatement measures shall be continued until the Contractor is relieved of further responsibility by the Owner.

If temporary heating devices are necessary for protection of the work, such devices shall be of an approved type that will not cause pollution of the air.

1-08 PROSECUTION AND PROGRESS

1-08.1 Subcontracting - Add the following:

The Contractor shall, as soon as practicable after the execution of this Contract, notify the Owner in writing of the names of any Subcontractors proposed to be employed in any part of the work and shall not employ any such Subcontractor without the prior approval of the Owner in writing and shall terminate the employment of any which the Owner may at any time object to as incompetent or unfit.

The Contractor agrees to require each Subcontractor to execute a contract in writing binding such Subcontractor to the terms of this Contract insofar as applicable to his work, and requiring such Subcontractor, to the extent applicable, to assume toward the Contractor all the obligations and responsibilities that the Contractor assumes toward the Owner, unless specifically noted to the contrary in a written subcontract approved in writing by the Owner.

The Contractor shall be fully responsible to the Owner for the acts and omissions of all Subcontractors and of persons directly or indirectly employed by them. Nothing in this Contract shall create any contractual relationship between any Subcontractor and the Owner.

The word "Subcontractor", as employed herein, shall mean one having a direct contract with the Contractor, including one who furnished material worked to a special design according to the plans or specifications of this work, but excluding one who merely furnished material not so worked.

1-08.2 Assignment - Delete.

1-08.3 Progress Schedule - Add the following:

A preconstruction conference shall be held within 10 days after the contract has been awarded but before the start of construction.

1-08.9 Liquidated Damages - Delete the first two paragraphs.

DIVISION 2

EARTHWORK

2-01 CLEARING, GRUBBING, AND ROADSIDE CLEANUP

2-01.1 Description - Delete and replace with the following:

The Contractor shall clear, grub and clean up those areas shown on the Plans.

"Clearing" means removing and disposing of all unwanted material from the surface, such as trees, brush, down timber, or other natural material.

"Grubbing" means removing and disposing of all unwanted vegetative matter from underground, such as sod, stumps, roots, buried logs, or other debris.

"Debris" means all nonusable natural material produced by clearing or grubbing.

2-01.2 Disposal of Usable Material and Debris - Amend as follows:

All organic debris and sod from clearing and grubbing shall be disposed of on-site at the direction of the Engineer.

2-01.2(1) Disposal Method No. 1 - Open Burning - Delete this section.

2-01.3 Construction Requirements

2-01.3(1) Clearing - Delete and replace with the following:

The Contractor shall:

1. Complete the clearing within the work area.
2. Fell trees with root structures within the work area.
3. Fell trees which are detrimental to the functionality of the surface water management system for the work area.
4. Close-cut parallel to the slope of the ground all stumps to be left in the cleared area outside of the work area.

2-01.3(2) Grubbing - Delete and replace with the following:

The Contractor shall:

1. Complete the grubbing work within the work area.
2. Grub deep enough to remove all stumps, large roots, buried logs, and other vegetative matter.
3. Grub all areas:
 - a. Shown on the plans.
 - b. To be excavated, including area staked for slope treatment.
 - c. Where subdrainage trenches will be dug, unsuitable material removed, or structures built.
 - d. Upon area where embankments will be placed.

2-01.3(4) Roadside Cleanup - Delete this section.

2-01.5 Payment - Amend as follows:

"Clearing and Grubbing", Lump sum.

The Contract lump sum payment for "Clearing and Grubbing" shall be full payment for clearing and grubbing the site to the limits required by the Engineer and disposing of all material in designated on-site stockpiles.

2-02 REMOVAL OF STRUCTURES AND OBSTRUCTIONS

2-02.1 Description -Delete and replace with the following:

The work described in this section includes removing and disposing of, or salvaging materials named in these special provisions or identified by the Engineer.

Demolition and removal of primary structures has been previously completed. However, structural components remaining include, but are not limited to, concrete foundations, walls, slabs, curb and gutter, sidewalks, equipment pedestals, and vaults. Other obstructions include fire hydrants, drain inlets, valve boxes, manholes, wood and metal fencing, wood and steel poles and bases, wood cribbing, and abandoned utility lines.

2-02.3 Construction Requirements

2-02.3(1) General Requirements - Delete and replace with the following:

The Contractor shall raze, remove, and dispose of all structure components, fences, utility components, and other obstructions that lie wholly or partially within the footprint. All structural components and obstructions encountered shall be removed, hauled, and segregated into designated on-site stockpiles for further processing. Metal components will be stockpiled for future recycling; concrete components will be stockpiled for future use; wood components will be stockpiled for future chipping and disposal. Such work may include the breaking up or otherwise reducing the size of the materials in a manner acceptable to the Engineer.

It is estimated that 7900 cubic yards of concrete will be removed from within the work area limits.

2-02.3(2) Removal of Bridges, Box Culverts, and other Drainage Structures - Delete this section.

2-02.3(3) Removal of Pavement, Sidewalks, and Curbs - Delete this section.

2-02.5 Payment - Amend as follows:

"Removal of Structures and Obstructions ", Lump sum.

The Contract lump sum payment for "Removal of Structures and Obstructions" shall be full payment for removing all structures and obstructions encountered and disposing of all material in designated on-site stockpiles.

2-03 ROADWAY EXCAVATION AND EMBANKMENT

2-03.1 Description - Delete and replace with the following:

This special provision covers the requirements for labor, supervision, equipment and materials associated with the earthwork operations shown on the Plans, or herein specified. Earthwork activities shall include, but not be limited to project layout, soil testing, site drainage, dust control, site preparation, excavation, excavation and disposal of any unsuitable materials encountered, subgrade preparation, fill and backfill, embankments, finish grading and site restoration.

All work described here must reasonably conform to the alignment, grade, and cross-sections shown in the Plans or established by the Engineer.

2-03.3 Construction Requirements - Delete and replace with the following:

2-03.3(1) Grade Control and Layout of Work.

The earthwork Contractor shall furnish all stakes, markers, tools and equipment required to lay out the work from bench marks and/or control point markers established by the Engineer. The earthwork Contractor shall not disturb existing survey monuments or bench marks without the consent of the Engineer. Markers that are accidentally disturbed by earthwork operations shall be replaced by the Owner at the Contractor's expense. The Owner and Contractor shall agree to the cost of reestablishing disturbed markers prior to the work being performed by the Owner.

2-03.3(2) Inspection and Testing.

During the course of the work, the Engineer will perform such tests as are required to identify materials, to determine compaction characteristics, to determine moisture content, and to determine density of the embankment in place. These tests performed by the Engineer will be used to verify that the embankment conforms to the requirements of the specifications and special provisions. Such tests are not intended to provide the Contractor with information required by him for the proper execution of the work and their performance shall not relieve the Contractor of the necessity to perform tests for that purpose.

The Owner may employ an independent laboratory for inspection and testing. The Owner will coordinate this testing with the Contractor, and the Contractor shall cooperate with the laboratory. The Owner will pay for these services. However, if initial testing indicates that the Contractor has not complied with the Contract

Documents, then the costs of subsequent testing associated with the non-compliance will be deducted from the Contractor's monthly pay request.

2-03.3(3) Protection and Safety

A. Open Excavations. The earthwork Contractor shall provide barricades and/or other safety equipment as required to protect any equipment, vehicles and workers from any open excavations.

B. Protection of Property. The earthwork Contractor shall protect adjacent property and avoid damage to such property. Adjacent property damaged due to the earthwork Contractor's operations shall be repaired or replaced at no cost to the Owner or to the property owner. The repairs and/or replacement shall be equal to existing improvements and shall match existing finish and dimensions.

2-03.3(4) Subgrade and Embankment Protection.

During construction, embankments and excavations shall be kept shaped and drained. Ditches and drains along subgrade shall be maintained in such a manner as to drain effectively at all times.

Finished subgrade shall not be disturbed by traffic or other operations and shall be protected and maintained by the earthwork Contractor until completion and acceptance of the work. The storage or stockpiling of materials on the finished subgrade will not be permitted.

2-03.3(5) Site Drainage.

Excavation, fill and backfill work areas shall be continually and effectively drained. Water shall not be permitted to accumulate in excavations or foundation areas for compacted fill. The earthwork Contractor shall construct suitable dikes, drains or provide pumping equipment, as required, to divert water flows away from the work areas.

2-03.3(6) Dust Control.

The dust produced from earthwork operations shall be controlled to prevent the spread of dust and to avoid creation of a nuisance in the surrounding area.

2-03.3(7) Excavation

2-03.3(7) A. General Requirements.

The earthwork Contractor shall excavate every type of material encountered within the limits of the footprint, to the lines, grades and elevations indicated.

Control staking will be set by the Engineer prior to construction to provide the Contractor with essential information for construction. The Contractor shall be responsible for the actual construction staking. Methods used shall be subject to approval of the Engineer, but shall not absolve the Contractor from responsibility for errors.

2-03.3(7) B. Stripping and Stockpiling Surface Courses.

1. After the clearing and grubbing activities have been completed on the vegetated surfaces and all surface structures and obstructions have been removed from the OCF work area, the entire work area shall be stripped. All stripped materials shall be segregated and disposed of in on-site stockpiles as designated by the Engineer.

The courses to be stripped include all vegetated areas (Zone A) that have been cleared and grubbed, and all asphaltic and gravel surfacing (Zone B).

Removal of concrete slabs, sidewalks, and other structural components are not a part of this work, but are part of the work addressed in Section 2-02 of these special provisions.

2. The surface courses in the cleared and grubbed areas are to be stripped to a minimum depth of 18 inches. The asphaltic and gravel courses are to be stripped to the bottom of the surfacing section. It is estimated that the average depth of all asphaltic and gravel surface courses is 6 inches.
3. It is estimated the volume of material to be stripped in Zone A is 13,200 cubic yards and in Zone B, including the surfacing course on the temporary construction access road, is 4000 cubic yards. The estimated volumes are based on the horizontal surface area shown on the Plans times the stripping depth.
4. After the work area has been stripped, the Owner will perform confirmational sampling of the new surface to determine levels of metals contaminants in the soil.

If the sampling indicates the soil in areas west of the Copper Refineries has metal contaminants above the action levels for arsenic (230 ppm) and lead (500 ppm) as stipulated in the Ruston/North Tacoma Soils Removal Project, additional stripping will be required. Any additional stripping will be performed in 6-inch increments to the area limits denoted by the Engineer, until additional confirmational sampling indicates metal concentrations are below the stipulated action levels.

The Contractor is cautioned that confirmational sampling results take one (1) working day to become known. He should, therefore, anticipate such delay and deploy his resources at other work or at locations on-site where necessary.

2-03.3(7) C. Excavations for Cell Construction.

1. The excavations shall be carried down to the elevations shown on the Plans. The subgrade shall be shaped to the line, grade, and cross-section shown in the Plans and compacted as specified. This work shall include plowing, discing, and any moistening or aeration required to obtain proper compaction. If suitable material in the bottom of the excavation is removed for the earthwork Contractor's convenience, the foundation shall be restored by the earthwork Contractor and at his expense, to a condition at least equal to the undisturbed foundation as determined by the Engineer.
2. It is estimated the volume of material to be excavated within the OCF footprint is 116,000 cubic yards.
3. The earthwork Contractor shall remove any surface layer of unsuitable material at the planned grade of the excavation, as determined by the Engineer, from the site and the cost thereof will be measured for payment, in accordance with Section 2-03.4, Measurement and Payment of these special provisions.
4. After the cell has been backfilled with source area soils and demolition debris, the temporary construction access road along the north side of the cell shall be removed. This work shall include the stripping and disposal, onsite, of the road surface course, as directed by the Engineer. The excavation of the road prism shall be to the line, grade, and cross-section shown in the Plans. Materials excavated from the road prism shall be placed onsite at the direction of the Engineer.

2-03.3(7) D. Excavations for Ditches and Drainage Structures.

Excavations for ditches and drainage structures shall be accomplished by cutting accurately the line, grade and cross section required. Trenches and pits shall be of sufficient size to accommodate the installation and the removal of piping and structures. Excessive open ditch excavation shall be backfilled with satisfactory materials to the grades shown on the Plans. The earthwork Contractor shall maintain all excavations free from detrimental quantities of brush, sticks, trash and other debris.

At each transition from cut to fill, the Contractor shall divert any drainage facility away from the embankment in natural ground. Ditches shall never permit water to flow into or upon embankment material.

2-03.3(7) E. Seeps and Abandoned Utilities Found in Excavations.

If the earthwork Contractor encounters seeps and/or abandoned utilities during excavation, he shall immediately notify the Engineer.

It is anticipated that water seeps will be encountered in the final slope face of the excavation. The Engineer shall evaluate and design the necessary drainage facilities to be constructed by the Contractor. Strip drains shall be installed to elevation 74 as

shown in the Plans. The specification for the necessary facilities are described in Section 8-06 of these special provisions. A plan and narrative of the work to be performed will be provided to the Contractor after agency approval, if required, has been granted. The Contractor is cautioned that agency approval may result in some delay. Contractor should, therefore, anticipate such delay and deploy resources at other work or at locations on-site where necessary. Claims for delays or contract time extensions will not be allowed for this work. Payment for installing the seep drainage facilities shall be by force account as provided in Section 1-09.6 of the Standard Specifications.

It is anticipated that abandoned utilities will be encountered during excavation of the cell. Utility components within the excavation limits will be removed and disposed of on-site at the direction of the Engineer. Utility components that extend beyond the face of the cut slope shall be plugged or capped or may be required to be piped beyond the limits of the footprint. The Engineer shall evaluate the conditions found in the field and will provide the Contractor, within 48 hours of the Contractor's notification, with a plan and narrative of the work to be performed. Payment for such work shall be by force account as provided in Section 1-09.6 of the Standard Specifications.

The plugging and capping may include: Plug pipe ends with concrete (concrete pipe and corrugated metal pipe), weld or hammer shut (steel pipe), cap (PVC and similar plastic pipe), or install blind flanges (ductile cast iron and HDPE).

2-03.3(8) Borrow.

2-03.3(8) A General Requirements.

Borrow is the excavation of material outside of the limits of the footprint as shown on the Plans or from Contractor-provided sites.

If the Contract Documents designate borrow materials are to be furnished by the Owner, the Contractor shall use those materials. Such borrow materials will be provided to the Contractor in stockpiles adjacent to the work. Borrow from other sources will be required only after stockpiled borrow materials are no longer available.

The earthwork Contractor shall load, haul, place, spread and compact the Owner-provided borrow materials from stockpiles as well as Contractor-provided off-site borrow materials for the construction of the earth berm embankment and in replacing unsuitable materials encountered during excavation.

2-03.3(8) B Materials.

Contractor-provided borrow materials shall meet the requirements of Section 9-03.14(3) of the Standard Specifications. The maximum particle size shall be limited to 3 inches.

2-03.3(9) Embankment and Fill

2-03.3(9) A. General Requirements.

The Contractor shall submit to the Engineer for approval, proposed equipment and construction methods to be used for the placement and compaction of embankment.

Embankment materials shall not be placed until the required excavation and foundation preparation have been completed and the foundation has been inspected and approved by the Engineer. Embankment shall not be placed on a frozen surface, nor shall snow, ice, or frozen material be incorporated into the embankment.

OCF cell backfill materials, consisting of source area soils and demolition debris, shall not be placed until the final liner components have been inspected and approved by the Engineer. Cell backfill materials shall not be placed on a frozen surface, nor shall any frozen materials be incorporated in the backfill.

2-03.3(9) B. Placement.

1. The embankment foundation surface shall be graded to remove surface irregularities and shall be scarified parallel to the axis of the embankment or otherwise acceptably scored and loosened to a minimum depth of 2 inches. The moisture content of the loosened material shall be controlled as specified for embankment materials, and the surface materials of the foundation shall be compacted and bonded with the first layer of embankment as specified for subsequent layers of embankment. The earthwork Contractor shall place earth embankments in horizontal layers of uniform thickness. These layers shall run full width from top to the bottom of the embankment. Slopes shall be compacted to the required density as part of embankment compaction.

The distribution of materials throughout the embankment shall be free of lenses, pockets, streaks or layers of material differing substantially in texture, moisture content, or gradation from the surrounding material. Embankment materials shall be placed in approximately horizontal layers. The thickness of each layer before compaction shall not exceed the maximum thickness specified in Section 2-03.3(9)D.

If the surface of any layer becomes too hard and smooth for proper bond with the succeeding layer, it shall be scarified parallel to the axis of the embankment to a depth not less than 2 inches before the next layer is placed.

During grading operations, the Contractor shall shape the surfaces of embankments and excavations to uniform cross-sections and eliminate all ruts and low places that could hold water. The top surfaces of embankments shall be maintained approximately level during construction, except that a cross-slope of approximately 2 percent shall be maintained to insure effective drainage.

Contractor shall raise the inside edge of the embankment sufficiently above the outside edge of the lift, thus promoting drainage away from the cell. When the surface of the embankment intersects a side hill, the surface shall be sloped away at a rate not to exceed 20:1.

2. The cell backfill materials shall be placed in 12 inch (loose) lifts, spread uniformly across the area being backfilled resulting in a homogeneous mass prior to compaction. Each lift shall be watered, if necessary, and compacted to 90% of standard Proctor maximum dry density. The cushion course placed across the top of the backfill, prior to placement of the cell cap, shall be compacted to ensure that the top 12" of the course is compacted to 95 percent of the standard maximum dry density. Field density and moisture content tests will be performed as the backfill operations proceed.

2-03.3(9) C. Materials.

1. Embankment materials for constructing earth embankments are those materials obtained from on-site excavation, Owner-provided borrow, or Contractor-provided off-site borrow. Final acceptance of all embankment materials will be determined by the Engineer.
2. The OCF cell backfill materials shall consist of materials from source area excavations and demolition debris. Backfill materials shall be processed and screened to provide for two (2) gradations of materials. One gradation requires that 100% of the backfill material pass a 3/4" screen. The second gradation requires 100% of the material to pass a 6" screen. It is anticipated that demolition debris and concrete found in the source areas will require size reduction operations to meet the required gradations.

The backfill materials passing the 3/4" screen shall limit fines to 10% and shall act as a cushion course between the installed liner systems, including the cell cap, and the larger graded backfill materials placed in the center of the cell. This material shall be placed adjacent to and to a minimum depth of 12" perpendicular to the liner systems along the bottom and the sides of the cell and shall have a 10' height restriction. The cushion course shall be a minimum depth of 3 feet across the top of the placed source area soils and demolition debris. The material passing the 6" screen shall be placed inside the cushion courses.

2-03.3(9) D. Compacting Earth Embankments.

Each layer of the entire OCF cell embankment shall be compacted to 95 percent of the maximum density as determined by the compaction control tests described in Section 2-03.3(9)F of these special provisions.

In the top 2 feet, horizontal layers shall not exceed 4 inches in depth before compaction. No layer below the top 2 feet shall exceed 8 inches in depth before compaction.

The Contractor shall use compaction equipment approved by the Engineer.

2-03.3(9) E. Moisture Content.

Within the limits described below, the Contractor shall adjust moisture content during compaction to produce a firm, stable embankment. The Contractor shall not begin compaction until the moisture content is so adjusted.

The optimum moisture content is defined as, "That moisture content which will result in a maximum dry unit weight of the soil when subjected to the ASTM D 698, Standard Proctor Compaction Test" (WSDOT Test Method 606/AASHTO T99 Method A). The maximum dry weight, in pounds per cubic foot, obtained by the above procedure is the Proctor maximum dry density.

All fill materials to be placed in the embankment shall be compacted within the range of three (3) percentage points below to two (2) percentage points above optimum. Where the layer of embankment must be moisture conditioned before compaction, uniformly apply water to surface of the layer to prevent free water appearing on the surface during or subsequent to compaction operations. The water shall be mixed into the embankment materials adequately to provide a uniform moisture content throughout the uncompacted layer.

Remove and replace, or scarify and aerate, embankment materials too wet to permit compaction to the specified density.

The Engineer may permit the Contractor to place materials having a higher moisture content than specified if:

1. The material consists of free-draining rock, gravel, or sand that produces a firm, stable embankment;
2. The excess moisture will not impair the embankment; and
3. EPA approval is granted.

However, the Engineer may at any time require the Contractor to return to normal moisture-content specifications.

All costs of drying (scarifying and aerating) embankment materials shall be considered incidental to other items of work.

If weather prevents drying excavation or borrow materials to the required moisture content, the Engineer may order the Contractor to alter normal procedures or equipment to prevent damage to the partial or complete embankment.

The Contractor shall repair at no expense to the Owner any partial or complete embankment that loses stability because of continued hauling across it. Evidence of lost stability shall include pumping or rutting. The Contractor shall also alter hauling equipment or procedures to prevent further damage.

If it appears that rain or snow will soak an area that has been placed and compacted, the Contractor shall temporarily seal it against the weather. Should the Contractor fail to do so, any additional work required to restore the area to its previous condition shall be done at no expense to the Owner.

2-03.3(9) F. Compaction and Moisture Control Tests.

Maximum density for materials with 30 percent or more, by mass, retained on the U.S. No. 4 sieve shall be determined using WSDOT Test Method No. 606. The maximum density and optimum moisture for materials with less than 30 percent, by mass, retained on the U.S. No. 4 sieve shall be determined using AASHTO T99 Method A.

In place density and moisture content will be determined using WSDOT Test Method No. 613.

The Engineer will inform the earthwork Contractor when the placement moisture content is near or exceeds the limits of uniformity specified above, and the Contractor shall immediately make adjustments in procedures as necessary to maintain the moisture content within the specified limits.

2-03.3(14)H Prefabricated Vertical Drains - Add the following:

The plans show the spacing of the prefabricated vertical drains (wicks) that shall be installed after the placement of granular blanket and prior to performing the Deep Dynamic Compaction.

Submittals. The Contractor shall submit the following:

Submit a 3-foot long sample of prefabricated vertical drain material to the Engineer for evaluation and approval of the material prior to site delivery. The sample shall be stamped or labeled by the manufacturer as being representative of the prefabricated vertical drain having the specified trade name.

Prior to the installation of the prefabricated vertical drain, submit to the Engineer 2 copies of details of the sequence and method of installation including:

1. Size, type, weight, maximum push force, and configuration of the installation rig;
2. Dimensions and length of mandrel;
3. Details of drain anchorage;
4. Detailed description of proposed installation;
5. Proposed method for overcoming obstructions; and
6. Proposed method of splicing drains.

As a minimum experience requirement for those who will actually perform the prefabricated vertical drain installation, identify three successfully completed projects, each with a minimum of installation of 50,000 lineal feet of prefabricated vertical drains. Provide to the Engineer prior to installation a list including project name, location, project description, size, owner, completion date, and owner's contract a manager by name, title, and current phone number.

Materials. Materials shall meet the requirements of Section 9-37 of these special provisions.

Equipment. The Contractor shall use only constant load or constant rate of advancement methods to advance the mandrel to a depth of 40 feet. Vibratory hammers will be allowed. Falling weight impact hammers will not be allowed. Jetting shall not be permitted, except upon approval of the Engineer, to lubricate the mandrel when working in highly plastic clays.

Installation. The Contractor shall install trial drains at locations designated by the Engineer. Installation of satisfactory trial prefabricated vertical drains will be measured and paid for at the same rate as for production drains. Payment will not be made for unsatisfactory installed prefabricated vertical drain.

2-03.3(14) I Deep Dynamic Compaction - Delete and replace with the following new section:

This work consists of completing deep dynamic compaction activities in areas designated by the Engineer and shown on the Plans. The work is to be completed and accepted prior to the placement of embankment materials for the OCF berm.

Submittals. Upon receipt of the Notice of Award, the Contractor shall submit to the Engineer 2 copies of the following:

1. Size, type, and rigging configuration of the crane to be used for the densification program;
2. Dimensions and mass of weights to be used;
3. Details on the drop height, drop pattern, number of passes, and schedule;
4. Detailed description of proposed methods to ensure dissipation of pore water pressures between passes;
5. Details on the test program to evaluate the proposed methods;
6. Details on the proposed field documentation program;
7. Details on proposed field safety program;
8. Details on proposed vibration monitoring program; and
9. Details on proposed quality control program.

The Contractor shall also notify the Engineer of any site preparation requirement in the location of the proposed work. This notification shall be in writing and include, but not be limited, to the following:

1. Removal of existing structures/foundations;
2. Leveling of the ground surface or other grading required for the Contractor's equipment to access the site; and
3. Minimum depth to ground water.

As a minimum experience requirement for those who will actually perform the deep dynamic compaction work, identify three successfully completed projects. The projects used shall include the project name, location, project description, size, owner, completion date, and owner's contract manager by name, title, and current phone number.

Site Preparation. The Contractor shall review with the Engineer and accept the work area at the time of mobilization, prior to the Contractor staking the drop pattern locations. The Owner shall correct any unsatisfactory conditions found immediately.

Equipment. Deep dynamic compaction shall be completed with approved modern equipment that is capable of delivering the applied energy to satisfy the requirements for densification of the soil mass as presented by this special provision.

Cranes shall be rigged so that at least 95 percent of the potential energy is realized at the point of impact.

Pre-compaction Activities. Contractor shall satisfy all requirements for Submittals noted above.

The Contractor shall perform pre-densification testing to establish the baseline condition in the areas planned for deep dynamic compaction. Pre-densification testing will consist of Standard Penetration Tests. Cone penetration testing will not be allowed. The Contractor will submit calibration data for the SPT hammer energy efficiency.

The Contractor shall a complete test section to verify or allow modification to the applied energy levels.

After satisfactory completion of the test section and approval by the Engineer, the Contractor may begin production tamping.

Contractor shall maintain and submit to Engineer on a daily basis, records of operations including location and number of drops, rate of penetration, pass number, and any additional pertinent information to document the work that may be requested by the Engineer.

Contractor shall demonstrate to the satisfaction of the Engineer and EPA that the required densification has been obtained for the entire soil mass.

Deep Dynamic Compaction. The Contractor shall provide equipment, materials and personnel required to achieve the requirements of this special provision.

The Contractor shall provide quality control services, and compile documentation during and after completion of the work to demonstrate to the satisfaction of the Engineer that the work was completed in accordance with the requirements of this special provision.

The Contractor shall complete a test section consisting of 3,000 square feet to verify or allow modifications to the energy levels required to achieve the required minimum densities.

The Contractor shall install prefabricated vertical drains in accordance with the requirements of Section 2-03.3(14)H, herein and as shown on Plans.

The following minimum requirements are applicable to the deep dynamic compaction program:

1. The Contractor shall complete deep dynamic compaction to achieve the minimum requirements of this specification to the satisfaction of the Engineer.
2. Densification by deep dynamic compaction shall be completed to a minimum depth of 35 feet.
3. The Contractor shall provide crane, weight, and rigging capable of a minimum applied energy of 350 tonne meters/meter² (1055 ft-Ton/Square Yard).
4. The Contractor shall complete a final ironing pass across the entire surface of the improvement area to densify the upper portion of the soil mass.
5. The Contractor shall complete preliminary and post densification quality control testing to evaluate the level of densification. Locations of baseline tests are to be surveyed and documented to allow for location of post densification testing.
6. Satisfactory densification and acceptance of the work will be determined when a minimum $(N_1)_{60}$ blow count value of 20 is attained, and approved by the Engineer for the entire 35 foot depth of soil mass to be densified.

A $(N_1)_{60}$ blow count refers to the standard penetration blow count that has been corrected for efficiency and standardized to an overburden stress of 1 tsf.

Approval by the Engineer will not relieve the Contractor of his responsibility to complete the deep dynamic compaction in accordance with the Plans and this special provision. If at any time, the Engineer considers that the methods do not produce satisfactory results, the Contractor shall alter his method and/or equipment as necessary to comply with the Plans and this special provision.

2-03.4 Measurement and Payment - Delete and replace with the following:

Stripping and Stockpiling Surface Courses - The materials stripped in the vegetated areas and to the full depth of the surfacing courses, including the temporary construction access road, will not be measured for payment.

"Stripping and Stockpiling of Surface Courses" (Zone A and Zone B) will be paid for, per Lump Sum.

Any additional stripping required as a result of confirmational sampling, will be measured by the area denoted by the Engineer, times 6 inches in depth and converted to cubic yards.

"Additional Stripping and Stockpiling of Surface Courses" will be paid for, per cubic yard. The unit contract price per cubic yard for "Additional Stripping and Stockpiling of Surface Courses" shall be full compensation for excavating, loading, hauling, and disposing the material in an on-site stockpile.

Excavation for cell construction and the removal of the temporary construction access road will be measured by the cubic yard. Material will be measured in its original position by cross-sectioning or through the use of digital terrain modeling survey techniques. In excavation, pay quantities will be computed to the neat lines of the cross-sections.

"Excavation for Cell Construction" or "Removal of Temporary Construction Access Road" will be paid for, per cubic yard. The contract unit price shall be full compensation for excavating, loading, hauling, placing, or otherwise disposing of the material.

Excavation of unsuitable materials will be measured by the area denoted by the Engineer, times the depth of excavation and converted to cubic yards.

"Excavation of Unsuitable Materials" will be paid for, per cubic yard. The unit contract price per cubic yard for "Excavation of Unsuitable Materials" shall be full compensation for excavating, loading, hauling, and disposing the material in an on-site stockpile.

Common borrow, if required, will be measured by the ton. Moisture content above +3 percent of optimum moisture will be deducted from the pay quantities.

"Common Borrow" will be paid for, per ton. The unit contract price per ton for "Common Borrow" shall be full compensation for excavating, loading, hauling, placing, or otherwise depositing the material on-site as directed. This price includes pay for permits, royalties, removing from the borrow site, disposing of, wasting or stockpiling any material not suitable for embankment, and borrow site reclamation.

Embankment construction and compaction will be measured by the cubic yard, to the neat lines of the staked cross-sections of compacted embankment. No allowance will be made for material that settles.

"Embankment Construction and Compaction" will be paid for, per cubic yard. The unit contract price per cubic yard for "Embankment Construction and Compaction" shall be full compensation for all material, labor, tools, equipment, and incidentals

required. The quantities for embankment construction and compaction shown in the proposal are estimates only. The Engineer will be the sole judge of the actual quantities needed.

Backfill materials placed in the cell will be measured by the cubic yard, to the neat lines of the staked cross-sections of compacted embankment. No allowance will be made for material that settles.

"OCF Cell Backfill" will be paid for per cubic yard. The unit contract price per cubic yard for "OCF Cell Backfill" shall be full compensation for all labor, tools, equipment, and incidentals required. The quantity shown in the proposal is the volume of the cell computed electronically to the limits denoted on the Plans.

Prefabricated vertical drains will be measured by the linear foot installed and accepted. Measurement will be measured from the top of the working platform to the bottom of each hole. Trial drains will be measured in the same manner as production drains.

"Prefabricated Vertical Drains" will be paid for, per lineal foot. The unit contract price per lineal foot shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals required to install the drains. Such payment shall include costs of altering the equipment and methods of installation in order to produce the required and accepted drain installation.

Drainage Blanket Material will be measured by the placed ton denoted by the Engineer.

"Drainage Blanket Material" will be paid for ton. The unit price per ton shall be full compensation for furnishing all materials, loading, hauling and placement.

Deep dynamic compaction will be measured by the square yard for the areas actually compacted and accepted by the Engineer, regardless of the number of passes required to obtain the desired densification.

Work completed during completion of a test program will not be included in the quantity for payment unless test area is included in the area shown on the Plans for production tamping and approved by the Engineer.

"Deep Dynamic Compaction" will be paid for, per square yard. The unit price per square yard shall be full compensation for the cost of furnishing the equipment, materials, personnel, and quality control services required to achieve the results specified in these special provisions. Such payment shall include costs for altering the equipment and methods of compaction to produce the required and accepted compacted areas. No compensation shall be made for areas of deep dynamic compaction that fail to meet the specifications, or for delays or expenses incurred through changes necessitated by improper or unacceptable methods or equipment used.

2-03.5 Payment - Delete this section.

2-06 SUBGRADE PREPARATION

2-06.1 Description - Delete and replace with the following:

The subgrade will be considered as those areas and surfaces upon which additional materials are to be placed under this contract, or which are to be constructed or prepared for the future placement thereupon of other material in accordance with the Standard Specifications and these special provisions.

All work shall be in accordance with the Contract Documents and constructed to the lines, grades, and typical cross-sections indicated in the Plans or as established and staked by the Engineer.

2-06.3 Construction Requirements

2-06.3(1) Subgrade for Surfacing - Delete and replace with the following:

1. General Requirements. Subgrade shall be shaped to the line, grade and cross section and compacted as specified. This operation shall include plowing, discing and any moistening or aeration required to obtain proper compaction. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory material as directed by the Engineer.

Low areas resulting from the removal of unsatisfactory material shall be brought up to the required grade with satisfactory materials, and the entire subgrade shall be shaped to the line, grade and cross-section and compacted as specified.

The foundation for the placement of embankment shall be prepared by leveling, moistening, and rolling so that the surface materials of the foundation will be as compact and will provide as satisfactory a bonding surface with the first layer of embankment as specified for the subsequent layers of embankment.

After rolling, the elevation of the finished subgrade shall not vary more than 0.2 foot from the established grade and approved cross-section.

2. Compaction. Compact the subgrade to a depth of 6 inches. Compaction accomplished by sheepsfoot rollers shall be not less than 95 percent of the Standard Proctor maximum dry density (WSDOT Test Methods 606/AASHTO T99 Method A or ASTM D 698).

2 06.3(2) Subgrade for Pavement - Delete this section.

2-06.5 Measurement and Payment - Delete and replace with the following:

This work is to be considered incidental to other items of work. No measurement or payment will be made for this work.

2-11 TRIMMING AND CLEANUP**2-11.1 Description** - Delete and replace with the following:

The Contractor shall, as directed by the Engineer, remove from the Owner's property and from all public and private property, at his own expense, all temporary structures, rubbish, and waste materials resulting from his operations.

2-11.3 Construction Requirements - Delete and replace with the following:

Throughout the period of construction, the Contractor shall keep the site clean and free from all rubbish and debris and shall promptly clean up all or any portion of the site when notified to do so by the Engineer. Care shall be taken to prevent spillage on the streets over which hauling is done, and any such spillage or debris deposited on streets due to Contractor's operations shall immediately be cleaned up. The Contractor shall promptly remove from any parts of the working area all unused materials, surplus earth and debris. Uncontaminated materials shall be removed from the site at the Contractor's expense. Contaminated materials shall be disposed of on-site in stockpiles designated by the Engineer. Materials may require size reduction prior to placement in stockpiles. Construction areas shall be left in a clean, neat and acceptable condition at the earliest time following completion of the portion of the work.

In the event that the Contractor fails to comply with the orders of the Engineer regarding clean-up, the Engineer may require the Contractor to cease progress on any or all parts of the work under the Contractor until the unsatisfactory condition is corrected. If the Contractor does not respond in a timely manner, the Engineer may order such clean-up work performed by others and the costs therefore deducted from payment due the Contractor. No additional compensation will be allowed as a result of such suspension.

During all phases of the construction work, the Contractor shall take precautions to abate a dust nuisance or a wind blown sand nuisance, by clean-up, sweeping, sprinkling with water, or other means as necessary to accomplish result satisfactory to the Engineer.

Upon completion of the work and prior to final inspection, the entire site of operations shall be cleared of equipment, unused materials and rubbish, so as to present a clean and neat appearance.

2-11.4 Measurement and Payment - Delete and replace with the following:

This work is to be considered incidental to other items of work. No measurement or payment will be made for this work.

2-11.5 Payment - Delete this section.

DIVISION 5**SURFACE TREATMENTS AND PAVEMENTS****5-06 ACCESS ROAD SURFACING - Add the following new section:****5-06.1 Description**

This work shall consist of constructing one or more layers of processed surfacing course on the temporary construction access road in accordance with these special provisions and in conformity with the lines, grades, depth, and typical cross-section shown on the Plans or as established by the Engineer.

5-06.2 Materials

Materials for the surfacing course shall consist of Owner-provided processed asphalt and gravel. Such materials will be available from onsite stockpiles designated by the Engineer. The maximum particle size shall pass a 1-1/4" square sieve size.

5-06.3 Construction Requirements

The asphaltic and gravel materials shall be uniformly spread upon the prepared access road subgrade to the depth, width, and cross-section shown on the Plans. Construction methods used shall meet the applicable requirements of Section 4-04.3 of the Standard Specifications.

5-06.4 Measurement and Payment

Measurement will be made by the number of cubic yards of asphaltic and gravel materials placed and approved by the Engineer. The volume will be computed to the neat lines of the plan cross-section times the length of the access road. Water used for compaction is to be considered incidental to the work and will not be measured for payment.

Payment will be made for "Access Road Surfacing", per cubic yard. Such price shall be full compensation for furnishing all materials, labor, tools, equipment, and other incidental work necessary to complete the work.

DIVISION 7
DRAINAGE STRUCTURES, STORM SEWERS, SANITARY SEWERS,
WATER MAINS AND CONDUITS

7-01 DRAINS

7-01.1 Description - Add the following:

This work also consists of construction of temporary dewatering facilities, the cell cap subsurface drainage system, and the cap pathway drainage system as shown and detailed on the Plans.

7-01.2 Materials - Add the following:

The drain pipe and underdrain pipe shall be Hi-Q pipe as manufactured by Hanker, Inc., 401 Olive Street, Findlay, OH 45840, Telephone 1-800-242-6267, or an approved equal.

The product supplied shall be a high density polyethylene corrugated exterior / smooth interior pipe.

Coupling bands shall cover at least one full corrugation on each section of pipe. All coupling bands shall meet or exceed the soil-tightness requirement of the ASHTO Standard Specification for Highway Bridges, Section 23, paragraph 23.3.1.5.4(e).

7-05 MANHOLES, INLETS, CATCH BASINS, AND DRYWELLS

7-05.2 Materials - Add the following:

Pathway drain inlet shall consist of a Nyloplast 12" x 12" Model H-20 storm drain inlet, as manufactured by Advanced Drainage Systems, 3300 Riverside Drive, Columbus, OH 43221, Telephone 614-457-3051, or an approved equal.

DIVISION 8

MISCELLANEOUS CONSTRUCTION

8-01 EROSION CONTROL

8-01.1 Description - Add the following:

This work shall be performed after the erosion control matting has been placed and accepted on the outside slopes of the OCF cell. Installation of the erosion control matting is outlined in Section 8-34 of these special provisions.

8-01.3(2) Topsoil - Add the following:

Topsoil for this work shall be Topsoil Type C.

8-01.3(4) Seeding - Add the following:

Hydroseeding is the only acceptable method of seeding on the slopes of the cell.

8-01.4 Measurement - Add the following:

Measurement for "Hydroseeding" will be by ground slope measurement in acres of actual area hydroseeded as approved by the Engineer.

8-01.5 Payment - Add the following:

"Hydroseeding", per acre.

The unit contract price per acre for "Hydroseeding" shall be full compensation for all costs necessary to prepare the area, hydroseeding the areas as shown, and for furnishing all labor, tools, equipment, and materials necessary to complete the work as specified.

Any incidental work required to complete the hydroseeding as specified herein but not specifically mentioned, shall be incidental to, and all costs thereof shall be included in the unit contract price.

8-04 CURBS, GUTTERS, AND SPILLWAYS

8-04.1 Description - Add the following:

This work includes replacing the existing driveway opening on the east side Bennett Street with cement concrete barrier curb and gutter. Limits of the new curb and gutter

will be marked in the field. Removal of the existing driveway is described in Section 2-02 Removal of Structures and Obstructions of these special provisions.

8-06 OCF CELL SLOPE SUBDRAIN SYSTEM - Add the following new section:

8-06.1 Description

It is anticipated that water seeps may be found along cut slopes during the excavation of the OCF cell. This work shall consist of furnishing and installing panel-shaped geocomposite drains in trenches on slopes, furnishing and installing a horizontal subdrain collector pipe, and excavating and backfilling the trenches in accordance with the Plan details and this special provision. The Engineer will determine the limits of the complete drain system.

8-06.2 Materials

Materials shall meet the requirements of the following sections:

Aggregates	9-03.13, 9-03.16 & 9-03.17	(SS) (SS)
Geocomposite Slope Drain	9-05.22	(SP)
Horizontal Subdrain Collector	9-05.21	(SP)

8-06.3 Submittals

The Contractor shall submit 2 copies of the following:

1. Samples and a complete description of the geocomposite slope drain, fittings for connecting separate pieces of the geocomposite slope drain, and transition fittings.
2. A description of how the trench drains will be constructed. This will include a description of the equipment used to install trenches on 3 horizontal to 1 vertical (3:1) slopes, the method of installing the geocomposite slope drain in the trench, and the method of backfill and compaction.

The Contractor shall furnish written instructions for storage and handling of the geocomposite slope drain and fittings a minimum of 7 days prior to shipment of the material to the Site.

8-06.4 Construction Requirements

8-06.4(1) Geocomposite Drain

The exact location, sequence of placing the slope drains, and the depth of each trench will be determined by the Engineer in the field.

Each slope trench shall be excavated a maximum of 4 inches wide to the depth denoted by the Engineer.

The geocomposite slope drain shall be installed in the trench as shown on the Plans. The Contractor shall provide the means to hold the panel flush against the trench wall during backfilling.

The slope trench shall be backfilled with sand as specified. Backfill shall be compacted in 1-foot lifts, using equipment designed for backfilling in narrow trenches, without damaging the geocomposite materials.

Fittings and transition fittings shall be installed before placing the geocomposite drain in the trench.

8-06.4(2) Horizontal Subdrain Collector Drain

The location of the horizontal slotted subdrain collector and the subdrain outlet pipe will be determined by the Engineer in the field.

The trench shall be excavated, lined with a non woven geotextile as specified in Section 9.33.1(3), and backfilled with bedding materials (WSDOT 9-03.16) and gravel backfill (WSDOT 9-03.17, Class B) as shown on the Plans.

The upstream end of the HDPE pipe shall be capped prior to placement in the trench.

The slotted pipe shall be placed in the seep interception trench that parallels the cell walls. The solid pipe shall be placed below the berm of the cell, connecting the slotted pipe to the storm water outfall, as staked by the Engineer.

The installation of the HDPE pipe shall be performed such that the HDPE pipe segments and fittings will be fusion welded together, as necessary, to form a continuous conduit and it will not be telescoped or damaged to the extent that its drainage efficiency will be impaired when completed.

The subdrain pipes shall be installed in the trench to the line, grades and elevations staked in the field and backfilled, as detailed on the Plans.

8-06.5 Measurement

The length of geocomposite slope drain, slotted subdrain collector pipe, and subdrain outlet pipe will be the number of linear feet of completed installation measured along the invert. Pipe or drain in excess of the length designated by the Engineer will not be measured or paid for.

Excavation of the pipe trench will be measured as structure excavation Class B by the cubic yard as specified in Section 2-09 of the Standard Specifications. Excavation of the slope trench will be measured by the linear foot of trench staked by the Engineer times the specified width and depth and converted to cubic yards.

Gravel and sand backfill for the drains and pipe will be measured by the volume placed within the neat line limits of the structure excavation or the limits of the slope drain as specified on the Plans.

8-06.6 Payment

Payment will be made in accordance with Section 1-04.1 of the Standard Specifications, for each of the following bid items that are included in the proposal:

"Slotted Subdrain Collector Pipe _____ In. Diam.", per linear foot.

"Subdrain Outlet Pipe _____ In. Diam.", per linear foot.

"Geocomposite Slope Drain", per linear foot.

"Gravel Backfill for Subdrain", per cubic yard.

"Sand Backfill for Slope Drain", per cubic yard.

"Structure Excavation Class B", per cubic yard.

"Structure Excavation for Slope Drain", per cubic yard.

8-12 CHAIN LINK FENCE AND WIRE FENCE

8-12.2 Materials - Add the following:

All fencing and gates shall conform to the specifications for Type I, modified by the addition of three strands of barbed wire making the total fence height equal to 7 feet.

8-12.3(1) F Barbed Wire - Add the following new section:

Barbed wire brackets shall be installed on each post at 45° from vertical and facing away from the smelter site. Secure barbed wire to each bracket after tightening.

8-15 RIPRAP

8-15.3(6) Quarry Spalls - Add the following paragraph to this section:

Quarry spalls shall be placed after a 4.5-ounce/square yard non-woven ditch lining has been placed longitudinally in the ditches or on the slope.

Quarry spalls shall be placed as shown on the plans and in such a manner that all relatively large stones shall be essentially in contact with each other, and all voids filled with the finer materials so as to provide a well graded compact mass. The quarry spalls shall be dumped in such a manner as will ensure the spalls coming to their specified

thickness. When placing rock materials, care shall be taken not to disturb or damage underlying materials or improvements.

8-30 OCF LINER INSTALLATIONS - Add the following new section:

8-30.1 Description

This work shall consist of constructing a bottom liner system and a cover system within the constructed OCF cell in accordance with these special provisions and details shown on the Plans. The bottom liner system shall consist of a composite bottom liner, a leak detection, collection and removal system, a composite top liner, and a leachate collection and removal system. The cover system shall consist of a composite low hydraulic conductivity layer, a drainage layer, and a top cover layer.

Liner installation in the bottom of the cell shall be in the following order:

- a. Composite bottom liner
 - 3' thick compacted soil layer
 - 60-mil textured (both sides) HDPE flexible membrane liner (FML)
 - 16 oz. nonwoven cushion geotextile
- b. Leak detection, collection and removal system (LDCRS)
 - 12" minimum granular drainage material layer with liquid removal devices
 - nonwoven separation geotextile
- c. Composite top liner -
 - 1' thick compacted soil layer
 - 60-mil textured (both sides) HDPE FML
 - 16 oz. nonwoven cushion geotextile
- d. Leachate collection and removal system (LCRS)
 - 12" minimum granular drainage material layer with liquid removal devices.
 - nonwoven separation geotextile

Liner installation on the sides of the cell shall be in the following order:

- a. Composite bottom liner
 - 3' thick compacted soil layer
 - 60-mil textured (both sides) HDPE FML

- b. Leak detection, collection and removal system (LDCRS)
 - geocomposite drainage net layer with liquid removal devices conduit
- c. Composite top liner -
 - geosynthetic clay liner (GCL)
 - 60-mil textured (both sides) HDPE FML
- d. Leachate collection and removal system (LCRS)
 - geocomposite drainage net layer with liquid removal devices conduit

The cover system installation shall be in the following order:

- a. Composite low hydraulic conductivity layer
 - 2' thick compacted soil layer
 - 40-mil textured (both sides) HDPE FML
 - 16 oz. nonwoven cushion geotextile
- b. Drainage (biotic) layer
 - 12" minimum granular drainage material layer
 - nonwoven separation geotextile
- c. Top cover
 - minimum of 2' of soil capable of sustaining plant species
 - vegetation.

8-30.2 Materials

Materials shall meet the requirements of the following sections:

Bentonite	9-34	(SP)
Flexible Membrane Liner	9-35.1	(SP)
Cushion Geotextile	9-33.1(1)	(SP)
Aggregates	9-03.16 & 9-03.1(3)C	(SS)
Separation Geotextile	9-33.1 Table 3	(SS)
HDPE Drainage Pipe	9-05.21	(SP)
Geocomposite Drainage Net	9-33.1(2)	(SP)
Geosynthetic Clay Liner	9-35.3	(SP)
Cover Soil	9-14.1(3)	(SS)

8-30.3 Construction Requirements

8-30.3(1) General

Before commencing the work specified under this section, the Contractor shall submit to the Engineer for his review and approval, within 5 working days of received Award

of Contract, as stated in Sections 1-05 and 1-06 of the Standard Specifications, 2 copies of all installation drawings, procedures, and a schedule for carrying out the work, for all geosynthetic materials to be supplied. This submittal shall also include the sizes and weights of all proposed equipment, operating methods, and proposed protection measures for operating any equipment on each of the liner components. Shop drawings shall have sheet layouts with proposed size, number, position and sequence of placing all field joints and the direction of the shop joints on each sheet. Shop drawings shall also show complete details and/or methods for anchoring the specific liner component at the edges, making field joints and repairing damaged materials.

Materials delivered to the Site shall be inspected by the Engineer for damage, unloaded and stored with a minimum amount of handling. Materials shall not be stored directly on the ground. During shipment and storage, all components shall be wrapped in the factory sealed heavy-duty protective covering. It is essential that the rolls of the geosynthetic clay liner provided be kept dry until covered with the HDPE FML. The storage area shall be such that the supplied components are protected from vandalism, mud, soil, dust and debris. Materials that are not to be installed immediately shall not be stored in the direct sunlight.

The Engineer reserves the right to perform acceptance tests on samples of the component materials prior to acceptance. In addition, as soon as the component material arrives on-site, samples will be randomly selected by the Engineer and submitted for testing to confirm that the right material was received and that it meets the property values specified.

The supplier(s) of geosynthetic materials to be incorporated into the OCF cell shall provide a technical representative on the jobsite that has previously installed a minimum of 2 million square feet of the specific component in similar containments, to ensure compliance with the manufacturer's directions for handling and installation. The technical representative shall be present when the specific component installation is started and whenever the component is being installed. The technical representative shall observe the work and shall report unsatisfactory conditions to the Engineer and shall make recommendations for improvements to the Contractor.

The technical representative shall inspect the surface upon which the specific component is to be installed for acceptability and shall provide the Engineer with written certification that the component was installed in accordance with the manufacturer's recommendations.

8-30.3(2) Preparation of the Cell

Prior to the installation of liner components, the bottom and sides of the OCF cell shall be shaped to the line, grade, and cross-section and compacted as specified. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory material as directed by the Engineer. Areas requiring the removal of unsatisfactory

materials shall be brought up to the required line, grade and cross-section and compacted as specified. The slope of the finished subgrade upon which the liners will be installed shall not be less than the specified slope for the bottom portion of the cell and not more than the specified slope for the side slope portion.

The face and floor of the cell shall be scarified just prior to the placement of the first lift of the compacted soil.

The finished installation of each layer must be inspected and approved by the Engineer prior to the placement of the next succeeding layer.

8-30.3(3) Liner Construction

8-30.3(3)A Materials

1. Materials to be used in the admix for the composite bottom, top, and low hydraulic conductivity layers must be consistent with the materials used for the construction of the test pad.

Materials shall consist of one-quarter inch minus sand and/or silty sand materials provided by the Owner in stockpiles adjacent to the work. Rock fragments having maximum dimensions of more than 1/4" inches shall not be placed in the layer. Rock fragments found in the stockpiled materials shall be removed prior to mixing with the bentonite admixture.

2. Drainage materials to be used above the flexible membrane liners shall be obtained from an off-site borrow source approved by the Engineer. The Engineer shall approve the source of the material based on test results provided by the Contractor. Tests shall be performed by an approved soils laboratory. Tests required for materials acceptance include, but are not limited to gradation, permeability and standard Proctor optimum density, and a permeability/density curve established for the material submitted. The drainage materials in-place shall have a hydraulic conductivity of 10 cm/sec or greater.

The drainage material shall consist of rounded to subrounded gravels having a particle size no larger than 1-1/2 inches. The gradation shall comply with Grading No.2 for coarse aggregate for concrete as noted in the Standard Specifications. The material shall be durable and sound, free from lumps and balls of clay, organic matter, and other deleterious substances. Material containing sharp, jagged rock, roots, debris or any other material which may be abrasive to or may puncture the flexible membrane liner shall not be used.

3. Cover soil shall consist of Topsoil Type C as outlined in these special provisions. The material shall be imported from an off-site source approved by the Engineer.

8-30.3(3)B Construction Sequence

A. General

The intent of the admix program is to obtain a low-permeability soil by mixing Owner-provided materials from on-site stockpiles with bentonite to obtain an in-place permeability of 1×10^{-7} cm/sec or less.

The admix percentage, moisture, density requirements, compaction equipment size and weight, and the number of equipment passes have been established to provide the desired permeability (see the test pad and laboratory test results).

The in-place compacted permeability is sensitive to the homogeneity of the admix process, and the curing time between admixing and placement. Therefore, the Contractor will provide an admix process that obtains complete and uniform mixing of the materials, and allows adequate curing time (minimum of 24 hours) such that the required permeability is achieved when placed at the specified moisture and percent relative compaction.

The admix plant shall be a pugmill-type plant using either a batch or continuous mixing process that allows the mix proportions and mixing time to be controlled. The mixing operation shall be consistent with the process used for the construction of the test pad.

The plant shall contain screens capable of screening material larger than 1/4 inch in diameter. All Owner-provided materials shall be screened prior to mixing. The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Water shall be added in a controlled amount to the materials being admixed to obtain the specified moisture range for the low-permeability layer. (The quantity of water added may change as experience is gained in the work, with the objective of having the most desirable moisture content during placement to achieve the required permeability without having to add additional water or to dry the material). The Contractor shall provide means for checking the amount of water being added at the plant. The measuring device shall be accurate to within 0.5 percent.

The requirements for batch plants are as follows:

The equipment shall include means for accurately weighing each soil material (screened Owner-provided materials and bentonite) in a weight box or hopper suspended on scales and of ample size to hold a full batch without hand raking or running over. Automatic weight proportioning devices shall be provided. No material will be allowed to leak into the mixer while a batch is being weighed. The weight shall be accurate to within 0.5 percent. Batch weights shall be corrected for moisture contents of the materials.

The batch mixer shall be capable of producing a uniform mixture. The clearance of the blades from all fixed and moving parts shall not exceed 1 inch.

The plant shall be capable of regulating the mixing time in 5-second increments.

The requirements for continuous mix plants are as follows:

The plant shall include a means for accurately (within 0.5 percent) proportioning the materials to be blended.

The plant shall include a means for calibration of the feeder-gate openings by weighing test samples. Provisions shall be made so that materials fed out of the bins may be bypassed to individual test boxes.

The mixer shall be capable of producing a uniform mixture. The clearance of the blades from fixed and moving parts shall not exceed 1 inch.

The plant shall be capable of controlling the mixing time. The mixing paddles shall be adjustable for angular position on the shafts and reversible to retard the mix flow.

The Contractor shall install each component in accordance with the Plans and the manufacturer's specifications.

All geosynthetic materials shall be deployed free of wrinkles and folds. On slopes, the materials shall be anchored at the top and unrolled down the slope. In the presence of wind, all materials shall be weighted with sandbags or other materials which will not damage the geosynthetics.

During installation of any geosynthetic component, the edges of the material shall be anchored as detailed on the Plans. The ends of the material shall be protected during placement to prevent the damage to the component prior to seaming, attachment, or anchoring of the edges by use of sandbags or other approved methods. Materials, equipment or other items shall not be dragged across the surface of the component or be allowed to slide down slopes of the component. All parties walking on any component shall wear soft soled shoes. Smoking will not be permitted within the cell during any liner component installation.

All components shall be installed in a relaxed condition and shall be free of tension or stress upon completion of the installation. Stretching of components will not be allowed. The components shall be laid without folds which could cause excessive stress or deformation. Care shall be taken not to disturb any seams during subsequent layer placements.

Any necessary repairs shall be made with the component material itself. Patches shall be cut so as to cover the area to be repaired by a minimum of 6" in all directions for FMLs and 12" in all directions for geotextiles, geonets, and GCLs. Patches shall be cut with rounded corners. Patches shall be made as per the manufacturer's instructions and are

subject to the Engineer's inspection and approval. Damaged sections shall be patched as outlined herein. When patching the GCL, granular bentonite shall be applied between the patch and liner, and two surfaces pressed together immediately. Any wrinkles shall be smoothed out.

The Contractor shall be responsible for constructing and backfilling all geosynthetic materials termination trenches in cooperation with the geosynthetic component installation contractor, as detailed on the Plans. The Contractor shall ensure that all geosynthetic materials termination trenches are free of any irregularities that may interfere with the installation of the materials. Trench backfill methods and materials shall be approved by the Engineer.

Upon completion of each component installation and prior to placement of the subsequent layer, the component shall be jointly inspected by the Engineer and the suppliers technical representative to determine the integrity of the field seams or other jointing methods, as well as the general condition of the component. All joints on the completed work shall be tightly bonded.

B. Cell Bottom

1. Compacted soil liner materials shall not be placed on the bottom of the OCF cell until the foundation preparation has been completed and the foundation has been inspected and approved by the Engineer. The foundation shall be scarified perpendicular to the slope of the foundation and loosened to a minimum depth of 2 inches. The moisture content of the loosened materials shall be controlled as specified for the compacted soil layer materials. The first lift of the compacted soil layer shall be placed continuously across the foundation, compacted and bonded with the foundation materials as specified for subsequent layers of compacted soil materials.

Placement and compaction of each lift shall be consistent with the procedures and equipment used in the test pad work.

Compaction of each lift shall be accomplished by using a sheepfoot roller.

2. Placement of the compacted soil materials shall be in lifts not to exceed 6" after compaction, discing and any moistening or aeration required to obtain proper compaction. Compaction of each lift shall be performed leaving the surface of the compacted lift in a scarified condition. Each lift shall be compacted to 95% of standard Proctor maximum dry density or greater if required by the results of the test pad fill. Field density and moisture content tests will be performed on each layer placed.

If, in the opinion of the Engineer, the prepared surface of any layer is too dry or smooth to bond properly with the next layer to be placed thereon, the surface shall

be moistened and/or worked with a harrow, scarifier, or other suitable equipment, in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next succeeding layer of material is placed.

The moisture content during placement shall be between the optimum moisture content and 3 percent above the optimum moisture content or as required by the results of the test pad fill. Placement of overwet material will not be permitted. Work shall be shutdown in the event of precipitation, where in the opinion of the Engineer, an overwet condition could result. Shutdown procedures shall include rolling the entire surface with a smooth drum compactor or other approved equipment suitable to make a smooth dense surface capable of shedding runoff without pointing. Following shutdown, any previously compacted surface material which has become overly wet and softened or has been partially eroded shall either be removed and replaced or scarified, air dried and recompacted, as directed by the Engineer. In any event, the surface of the existing layer shall be scarified before placement of the next lift.

Soils which are drier than optimum shall be moistened by the addition of water and thorough blending to produce uniform moisture distribution prior to compaction.

All compacted low permeability soil surfaces shall be protected from drying to prevent cracking. This may be accomplished by temporarily covering the compacted surface or by watering as directed by the Engineer.

The final surface of the composite bottom, top, and low hydraulic conductivity layers shall be compacted and graded smooth to the elevations shown on the Plans. Upon approval of the final layer elevation, the final surface shall be hand raked, wetted if necessary, and rolled with a smooth drum roller to achieve a smooth uniform surface ready to receive the FML.

3. The Contractor shall cooperate with the Engineer and the geomembrane installation contractor to ensure the FML installation follows the compacted soil layer construction in a timely manner. This includes notifying the geomembrane installation contractor when the surfaces are ready for the FML installation.

If the Engineer deems the hydraulic integrity of the compacted soil layer has been adversely affected by a delay in the FML installation, the geomembrane contractor shall repair the prepared surface, at no cost to the Owner, in accordance with the Engineer's instructions. This may include scarifying and recompacting with the addition of water, as appropriate.

The FML shall be installed, seamed, tested, and protected in accordance with the manufacturer's and supplier's instructions and in accordance with Section 9-35.1(6) of these special provisions. In the event of conflict, the more stringent procedure shall apply unless approved otherwise by the Engineer and EPA.

4. Equipment will not be allowed to operate directly on the surface of the FML or other components of the liner system.

After the FML has been installed by the Contractor and approved by the Engineer, the nonwoven geotextile cushion fabric shall be placed on the FML. The cushion fabric shall meet the requirements of Section 9-33.1(1) of these special provisions.

Adjacent cushion fabric panels may be sewn or overlapped. For overlapped seams, the overlap distance shall be a minimum of 18 inches.

5. Placement of subsequent materials and equipment shall require the use of overhead crane systems. A pad shall be constructed on the appropriate liner to protect the underlying liner components, prior to placing equipment on the pad. The maximum height of drop of the pad materials shall be less than 3 feet from the surface of the liner. Drop heights very close to the liner components will not be allowed.

A small track dozer shall be used for spreading material over the liner components. Such equipment shall have a ground contact pressure that does not exceed 6 to 8 pounds per square inch. Materials shall be placed at the edge of the pad by the crane system in such a manner to allow straight-line movement along the cell bottom. To the extent possible, material shall be placed by the crane system on areas previously covered and the dozer shall be used to push the material over uncovered liner components. Only gradual turns will be allowed and equipment braking shall be minimized.

6. The Contractor shall place a 12" drainage layer over the cushion fabric in a single lift, taking extreme care to protect the FML and cushion fabric. Compaction shall consist of one pass with loaded haul equipment or a smooth drum roller.
7. After the drainage layer has been installed by the Contractor and approved by the Engineer, the drainage layer shall be overlain with a nonwoven geotextile separation fabric. The separation fabric shall meet the requirements of Section 9-33.1 of the Standard Specifications.

During the construction of the drainage layer, the leak detection, collection and removal system shall be installed as detailed on the Plans and in accordance with these special provisions.

Items 1 through 7 above describe the construction of the composite bottom liner. Construction of the composite top liner shall follow the same order of work as outlined in Items 2 through 7 above.

During construction of the drainage layer in the composite top liner, the leachate collection and removal system shall be installed as detailed on the Plans and in

accordance with these special provisions. After installation of the leachate collection and removal system separation geotextile, a 12" thick layer of processed soil (see Section 2-03.3(9)C, Item 2 of these special provisions) shall be placed for protection. The height of placement for the operational layer shall be limited to 10'.

C. Cell Side Slopes

On the side slopes of the cell, the composite bottom liner shall be constructed as outlined in **B. Cell Bottom** - Items 1 through 3 above. While installing the FML, two single pipe boots shall be installed as detailed on the Plans, at the locations staked in the field. The installation of the two riser pipes between the boots and Vault #1, will be performed concurrently with the pipe boot installation. After the FML has been installed by the Contractor and approved by the Engineer, the geocomposite drainage net shall be placed on the FML.

1. The drainage layer on the side slopes shall consist of the installation of the geocomposite drainage net with nonwoven geotextile material bonded to both sides.

The geocomposite drainage net shall meet the requirements of Section 9-33.1(2) of these special provisions.

Care shall be taken to keep the drainage net clean and free from debris prior to installation. If the drainage net is not clean before installation, it shall be washed by the Contractor just prior to installation.

Adjacent roll shall be overlapped no less than 3 inches, roll ends should be overlapped no less than 6 inches, and secured by plastic ties at least every five (5) feet along the roll length and at least every 6 inches along the roll ends and in the anchor trench. Plastic ties shall be white or other bright color for easy inspection. Metallic ties shall not be used.

In the corners of the side slopes, where overlaps between rolls are staggered, an extra layer of drainage net shall be installed from the top to the bottom of the slope.

The Contractor shall place subsequent liner components in such a manner to ensure that the drainage net and other underlying materials are not damaged in any way.

The installer shall handle the drainage net in such a manner as to ensure it is not damaged in any way. The geocomposite material shall be rolled down the side slope over the FML in such a manner as to continually keep the geocomposite in tension. If necessary, the drainage net shall be positioned by hand after being unrolled to minimize wrinkles. The geocomposite materials shall not be placed in the horizontal direction (i.e., across the slope).

Continuation of the installation of the LDCRS shall be performed concurrently with the geonet installation. The LDCRS riser pipe shall be connected to the single pipe boot as detailed on the Plans. The LDCRS shall be constructed as detailed on the Plans.

2. After the placement of the drainage layer has been approved by the Engineer, installation of the composite top liner may commence.

The Contractor shall install the geosynthetic clay liner (GCL) in accordance with the manufacturer's directions and in accordance with these special provisions. In the event of conflict, the more stringent procedure shall apply unless approved otherwise by the Engineer and EPA. The liner shall be placed on the side slopes in such a manner as to assure minimum handling. Dragging of the liner over the previously installed liner should be minimized. No lining material shall be placed when the air temperature is less than 40 degrees F, when the relative humidity is greater than 80%, when it is raining, when there is frost on the ground or when conditions may have a detrimental affect on the finished product.

On the side slopes, the GCL shall be anchored at the top and then unrolled so as to keep the material free of wrinkles. Seams shall be perpendicular to the toe of the slope at all times. No horizontal seams will be allowed on slopes. Seams at the base of the slope shall be a minimum of 5 feet away from the toe.

Seam areas or runs shall also be free of debris. Contacting surfaces shall be clean with all edges pulled tight to maximize contact and to smooth out any wrinkles or creases. Overlaps shall be a minimum of 12 inches and verified by the Installer. A proper seam will cover the six and nine inch lap lines.

Seams shall be augmented with granular bentonite to ensure seam integrity. Granular bentonite shall be dispersed evenly from the panel edge to the lap line at a minimum rate of 1/4 pound per lineal foot continuously along the seams or overlap areas. Accessory bentonite shall be of the same type as the material within the composite liner itself. Adhesives may be used on the seams to keep the panel in contact during the placement of the subsequent liner components if necessary.

The GCL shall be laid only over an area that can be completed (including installation of the FML) in one working day. Completion shall be defined as the full installation including anchoring of the liner and placement of the FML.

Upon completion of the GCL installation and prior to placement of the FML, the GCL shall be inspected by the Engineer to determine the integrity of the field seams (overlaps), as well as the general condition of the liner. All joints on completion of the work shall be tightly bonded. Any liner surface showing injury due to scuffing, penetration of foreign objects or other notable distress shall, as directed by the

Engineer, be replaced or covered and sealed with an additional layer of GCL material.

All rips and tears shall be repaired by completely exposing the affected area, removing all foreign objects or debris, and then placing a patch over the damage, with a minimum overlap of 12 inches on all edges. Accessory bentonite shall be placed between the patch and the repaired material at a rate of 1/4 pound per lineal foot of edge over a six-inch width. The edges of the patch shall be fastened to the repaired liner with construction adhesive, in addition to the bentonite-enhanced seam.

3. The Contractor shall cooperate with the Engineer and the geomembrane installation contractor to ensure the FML installation follows the GCL installation in a timely manner. This includes notifying the geomembrane installation contractor when the surfaces are ready for the FML installation.

The FML shall be installed, seamed, tested, and protected in accordance with the manufacturer's and supplier's instructions (see Section 9-35.1(6) of these special provisions) and in accordance with these special provisions. In the event of conflict, the more stringent procedure shall apply unless approved otherwise by the Engineer and EPA.

While installing the FML, one single pipe boot shall be installed as detailed on the Plans at the location previously denoted in the field. The boot shall be attached to the previously installed pipe leading to Vault #1 as detailed on the Plans.

4. Installation of the drainage layer shall be performed as outlined in **C. Cell Side Slopes** - Item 1 above.

Continuation of the installation of the LCRS shall be performed concurrently with the geonet installation. The LCRS riser pipe shall be connected to the double pipe boots as detailed on the Plans. The LCRS shall be constructed as detailed on the Plans.

5. After the placement of the drainage layer has been inspected and approved by the Engineer, backfilling of the cell may commence in accordance with Section 2-03.3(9) of these special provisions.

D. Cell Cover

1. After the cell has been backfilled with all minus 6" source area materials, a final cushion course of 1" minus materials shall be placed. The cushion course (cover system foundation) shall be a minimum of 3' thick, shaped to the line, grade, and cross-section shown on the Plans, and compacted to 95% of standard Proctor maximum dry density.

Compacted soil layer materials shall not be placed on the top of the OCF cell backfill until the cover system foundation preparation has been completed and the cover system foundation has been inspected and approved by the Engineer. The cover system foundation shall be scarified perpendicular to the slope of the cover system foundation and loosened to a minimum depth of 2 inches. The moisture content of the loosened materials shall be controlled as specified for the compacted soil layer materials. The first lift of the compacted soil layer shall be placed continuously across the cover system foundation, compacted and bonded with the cover system foundation materials as specified for previous layers of compacted soil materials.

Compaction of each lift shall be accomplished by using a sheepfoot roller.

2. Placement of the 2' thick compacted soil layer shall be performed as outlined in **B. Cell Bottom** - Item 2 above.
3. Placement of the 40-mil textured HDPE FML and the nonwoven geotextile cushion fabric shall be performed as outlined in **B. Cell Bottom** - Items 3 and 4 above.
4. Placement of the 12" drainage (biotic) layer and the nonwoven geotextile separation fabric shall be performed as outlined in **B. Cell Bottom** - Items 6 and 7 above. Placement of the cover system subsurface drainage facilities in the drainage layer, shall also be performed to the grades and lines shown on the Plans and as staked by the Engineer.
5. The top cover material for the cover system shall be Topsoil Type C. Placement of the topsoil shall be performed as outlined in Section 8-01 of the Standard Specifications.

8-30.4 Warranty

The installer of each geosynthetic component shall warrant his workmanship to be free of defects for two (2) years after the completion and acceptance of the work. This warranty shall include, but not be limited to, all seams, anchor trenches, and patches. The installer shall provide all warranty work and associated costs required by the Owner at no expense to the Owner. The installer shall also obtain and furnish the Owner a warranty from the component manufacturer for the materials used. The materials warranty shall be for defects or failure of the materials due to weathering for ten (10) years after the completion of the work on a prorata basis. All defects or failure of the material due to weathering shall be repaired at the Installer's sole expense.

8-30.5 Measurement

Measurement of each geosynthetic component installed will be made by the square yard of the surface area covered and accepted. The surface area covered is defined as the true area of all surfaces covered plus the designed burial in the anchor trenches. Materials required for overlaps will not be measured.

Measurement of the compacted soil layers, drainage materials, and cover soil will be made by the cubic yard, in place, determined by the neat lines required by the Plans.

8-30.6 Payment

The unit price per square yard for each of the specified geosynthetic components shall be full compensation for materials, labor, equipment, tools, and incidentals necessary to complete the work as specified. Such payment shall include work necessary to repair any damaged surfaces prior to the Engineer's acceptance.

The unit price per cubic yard for compacted soil layer, drainage material, and cover soil shall be full compensation for materials, labor equipment tools, and incidentals necessary to complete as specified. Such payment shall include payment of any royalties for materials and all costs of producing the required soil mix that results in the specified low-permeability compacted layer, in place.

8-31 TEMPORARY CELL COVER - Add the following new section:

8-31.1 Description

This work shall consist of installing a 20-mil polyvinyl chloride (PVC) flexible membrane cover system within the cell after the cell has been excavated but before the start of the liner installation, in accordance with this special provision. It is further anticipated that the temporary cover may be left in place along the upper reaches of the cell, to protect the exposed surfaces, while the cell subsurface drainage system installation is taking place at lower elevations. Immediately prior to the installation of the liner components, the temporary cell cover shall be removed and stockpiled for future use. After the last liner component has been installed (geocomposite drainage net), the temporary cell cover shall be reinstalled prior to the installation of the liner ballast windsocks.

It is anticipated that the temporary liner will be used during the winter months after construction activities have been completed. During the first winter the liner shall be constructed to minimize the ponding of precipitation within the constructed cell. Water collected on the liner will flow to the low point of the cell, where it will be pumped out to the on-site storm water system. During the second winter the liner shall be installed to prevent precipitation from being introduced to the constructed leachate collection system. Again, the water will flow to the low point within the cell where it will be pumped out to the storm water system.

No filling of the OCF is anticipated between the January 1 and May 31 period. If a very dry spring is experienced, filling may be considered after April 15 provided the extended 30 day forecast is predicting less than 40% chance of precipitation.

8-31.2 Materials

The material shall meet the requirements of Section 9-35.2 of these special provisions.

8-31.3 Construction Requirements

The liner system shall be installed and removed in such a manner that it can be reused with a minimum amount of damage or waste. The bottom portion shall be installed first, and overlapping this portion with the side panels. The bottom panels shall be installed up the side slopes a minimum of 6 feet from the floor elevation of the cell.

Adjacent panels shall be overlapped and flat rolled a minimum of 3 times prior to the placement of sandbags. On the bottom, the overlap shall be accomplished by folding the higher (uphill) panel back 18" and covering this fold with the lower panel. The flat roll shall then proceed downhill as detailed on the Plans. On the sideslopes, the adjacent panels shall also be overlapped and flat rolled as specified for the bottom panels. Edges of the panels along the top of the cell shall be anchored in a temporary cutoff trench.

Sandbags shall be placed on the flat rolls at a minimum spacing of 6'. Sandbags placed on the side slopes shall be tied to a tether that runs up the entire length of the slope and is adequately secured along the top of the slope. Sandbags will not be required, after the liner installation, on any run that will be covered with a windsock.

During the backfilling of the cell, the cover on the bottom of the cell will be removed, saved, and replaced as necessary. Cover panels and the windsocks on the side slopes shall be rolled up as the backfilling operations proceed. Panels and windsocks may be cut and disposed of, provided the remaining components still maintain the cover required to protect the side slopes and to minimize the generation of leachate.

No part of the temporary cell cover or windsock will be allowed to remain as a component of the final liner system.

8-31.4 Measurement

Temporary cell cover will be measured by the square yard of the surface area covered and accepted. Materials required for overlaps will not be measured.

8-31.5 Payment

The unit price per square yard for temporary cell cover shall be full compensation for materials, labor, equipment, tools, and incidentals necessary to complete the work as

specified. Payment for sandbags shall be covered under the unit price per square yard for installed temporary cell cover. Such payment shall include work necessary to repair any damaged surfaces prior to the Engineer's acceptance.

8-32 OCF LEACHATE COLLECTION SYSTEMS - Add the following new section:

8-32.1 Description

This work consists of installing leachate collection systems and sumps in the composite bottom and top liners of the cell, as shown and detailed on the Plans. Included in this work is the installation of the vaults, pumps, compressor, storage tank for the collected leachate, and the necessary electrical equipment, controls, alarms, and telemetry devices.

The work also includes the installation, operation, maintenance, and removal of temporary leachate collection system during the cell backfilling operations. During this time, leachate will be collected from the cell and pumped to the leachate collection tank in Vault #2. The temporary system will remove the leachate from the tank and pipe it to the evaporation system as shown on the Plans.

8-32.2 Materials

Materials shall meet the requirements of the following sections:

Aggregates	9-03.1(3)C	(SS)
HDPE Casing Pipe	9-05.21	(SP)
Polyvinyl Chloride (PVC) Pipe	9-30.1(5)B	(SS)
Pumping Equipment	9-36.1	(SP)
Compressor	9-36.2	(SP)
Precast Concrete Access Box	9-36.3	(SP)
Precast Concrete Vault	9-36.3	(SP)
Leachate Storage Tank	9-36.4	(SP)
Miscellaneous Leachate Collection Equipment	9-36.5	(SP)

The casing pipe shall be nominally 6" and 10" diameter HDPE pipe where shown on the Plans, with SDR of 17. Joining method shall be butt fusion method.

The piping conduit installed in the casing pipe shall be a nominal 1-1/2" diameter Schedule 80 PVC 1120 pipe. Joints shall be solvent weld.

The temporary pipe between Vault #2 and the evaporation system shall be nominally 2" diameter HDPE pipe. Joining method shall be butt fusion method.

8-32.3 Scheduling

The Contractor shall construct and test all components of the leachate collection system, including the temporary system, prior to inspection and acceptance of same by the Engineer. Placement of the cell backfill materials will not take place until the collection systems have been tested and approved by the Engineer.

8-32.4 Construction Requirements

Precast concrete facilities shall be installed as detailed on the Plans. Casing pipes shall be installed in the trenches to the lines, grades and elevations shown on the Plans and backfilled as outlined in Section 7-01 of the Standard Specifications.

Materials excavated for the casing pipe installation will be hauled and stockpiled on-site as directed by the Engineer.

Install liquid measuring devices to proper elevations. Set pumps and connecting PVC piping that allows free movement within outer casing pipe.

Set internal liquid sensor float to activate the pumps when the liquid level reaches an elevation of 9 inches above the bottom of the drainage layer. Set lower stop to shut pump off when 1 inch or less of leachate remains on the bottom of the drainage layer.

The telemetry system shall be installed to alert the Owner when the leachate level in the tank reaches the 3/4 full capacity (750 gallons) and to deactivate the pump when the liquid level in the tank reaches 95% full. The Owner will designate the facility within the Town of Ruston where the receiver module is to be installed.

The Contractor shall conduct initial startup of the equipment and perform necessary operational checks. The Contractor shall provide a written statement that all equipment has been installed properly, started up and is ready for operation and inspection by the Engineer. The Contractor shall also instruct the Owner's personnel at the jobsite on the operation and maintenance of each system.

8-32.5 Measurement

The casing pipe will be measured by the linear feet of completed installation along the invert. Pipe placed in excess of the length designated by the Engineer will not be measured or paid for.

Gravel backfill for the leachate trench will be measured by the volume placed within the neat line limits of the structure excavation Class B.

The length of each leachate collection system will be the number of lineal feet of completed installation measured along the invert of the pumping conduit, and will include the length of the pipe through elbows, tees, and fittings. The number of lineal

feet will be measured from the end of the pump through the access vault to the exterior wall of the precast concrete vault containing the storage tank.

No specific unit of measurement will apply for the lump sum items of furnishing and installing the precast concrete vaults.

No measurement will be made for pumps, compressor, and leachate storage tank.

No measurement will be made for the electrical equipment, controls, alarms, and telemetry devices.

8-32.6 Payment

Payment will be made for "HDPE Casing Pipe ____ In. Diam.", per foot.

Payment will be made for "Gravel Backfill for Casing Pipe", per cubic yard. Such payment shall include costs of installing filter fabric that encapsulates the gravel backfill in the trench.

Payment will be made for each "Leachate Collection Pumping System", per lineal foot. The unit contract price per lineal foot for the leachate collection system shall be full payment for all work to complete the work, including pump, liquid level controls, piping and fittings, pump testing, and providing O&M procedure instructions to the Owner's representative.

The lump sum contract price for "Vault #1" and "Vault #2" shall be full payment for all labor, materials, and equipment necessary to complete the work as shown on the Plans and as directed by the Engineer. Costs for furnishing the required ventilation equipment, the compressor in Vault #1, and the 1000-gallon storage tank in Vault #2 shall also be included in the respective lump sum price for the vaults.

The lump sum contract price for "Miscellaneous Leachate Collection Equipment" shall be full payment for all labor, materials, tools, equipment necessary to complete the work as outlined. The lump sum price shall include installing all necessary materials and equipment resulting in a fully operational leachate collection system.

8-33 OCF CAP SUBSURFACE DRAINAGE SYSTEM - Add the following new section:

8-33.1 Description

This work shall consist of installing a subsurface drainage system in the drainage (biotic) layer of the cell cover system and a storm drain collection system, as shown and detailed on the Plans. Included in this work is the installation of cleanouts, manholes, perimeter road surface drain inlets, and the storm drain connection to the outfall system.

8-33.2 Materials

Materials shall meet the requirements of the following:

Aggregates	9-03.1(3)C	(SS)
Perforated Corrugated PE Under-drain Pipe	9-05.2(7)	(SS)
Corrugated PE Drain Pipe	9-05.1(6) & 9-05.1(7)	(SS)
Precast Concrete Manhole	9-12.4	(SS)
Pathway Drain Inlet	7-05	(SP)
Cleanouts		

8-33.3 Construction Requirements

8-33.3(1) Storm Drain Collection System

The location of the storm drain collector system and the manholes will be determined by the Engineer in the field. The storm drain collector system will be connected to the outfall system that is described in PA 6.0, Group 2, Surface Water Drainage and Control. The OCF cap surface drain inlets will also be connected to the storm drain collection system.

A trench of the dimensions shown on the Plans shall be excavated to grade and lines given by the Engineer. Drain pipe shall be laid in conformity with the lines and grades shown on the Plans. The drain pipe shall be laid with watertight joints

Gravel backfill shall be used under the pipe. Gravel backfill shall be placed to the depth shown on the Plans or as directed by the Engineer. All backfill shall be in 12-inch maximum layers and be thoroughly compacted with three passes of a vibratory compactor for each layer.

8-33.3(2) Perimeter Trench System

The location of the perimeter trench system will be determined by the Engineer in the field. Cleanouts shall be installed at the starting points of the perimeter drain.

The perforated pipe shall be placed in the bottom of the perimeter trench above the FML liner and backfilled with granular drainage material.

All perforated pipe shall be laid with the perforations down. Upon final acceptance of the system, all pipes shall be open, clean, and free draining.

PE drainage pipe shall be jointed with snap-on, screw-on, or wraparound coupling bands, as recommended by the pipe manufacturer.

8-33.4 Measurement

The length of drain pipe or underdrain pipe will be the number of linear feet of completed installation measured along the invert. Pipe placed in excess of the length designated by the Engineer will not be measured or paid for.

Manholes will be measured per each. In addition to the measurement per each, manholes in excess of 10 feet in height will be measured per lineal foot for each additional foot over 10 feet. Measurement of manhole heights for payment purposes will be the distance from the flow line of the outlet pipe to the top of the manhole ring measured to the nearest foot.

Pathway drain inlets and cleanouts will be measured, per each.

Excavation of the pipe trench will be measured as structure excavation Class B by the cubic yard as specified in Section 2-09 of the Standard Specifications.

Gravel backfill for the perimeter drain and storm drain pipe will be measured by the volume placed within the neatline limits of the structure excavation.

8-33.5 Payment

Payment will be made in accordance with Section 1-04.1 of the Standard Specifications, for each of the following bid items that are included in the proposal:

"Storm Drain Pipe ____ In. Diam.", per linear foot.

"Underdrain Pipe ____ In. Diam.", per linear foot.

"Manhole ____ In. Diam. Type ____", per each.

"Manhole Additional Height ____ In. Diam. Type ____", per linear foot.

"Cleanout", per each.

"Pathway Drain Inlet", per each

"Gravel Backfill for Perimeter Drain/Storm Drain", per cubic yard.

"Structure Excavation Class B", per cubic yard.

8-34 OCF CELL SLOPE COVER - Add the following new section:

This work shall consist of installing erosion control matting on the outside slopes of the OCF cell in accordance with these special provisions and as detailed on the Plans and in conformity with the lines and dimensions established by the Engineer.

8-34.1 Materials

Materials shall meet the requirements of the following sections:

Erosion Control Matting 9-14.5(4) (SP)

Seed	9-14.2	(SP)
Fertilizer	9-14.3	(SP)
Mulch and Amendments	9-14.4	(SP)

8-34.2 Construction Requirements

All surfaces to be treated shall be compacted as required elsewhere in these Specifications, shaped to the specified finished grades, and shall be free of undesirable weed or plant growth and all clods, rocks, and debris 3 inches or larger in any dimension.

The erosion control matting shall be installed in accordance with the manufacturer's instructions. Panels will be anchored at the top of the slope and shall be rolled down the slope. The bottom of the panel shall be incorporated as part of any surface water control system required around the base of the slope. The bottom (outside) edge of the panels shall be terminated in accordance with the manufacturer's instructions.

Panels shall be anchored in a minimum 12 inch deep trench at the top of the slope around the entire perimeter. Adjacent panels shall be installed snugly with a 4 inch overlap and staked in place as detailed on the Plans.

After the erosion control matting has been installed and accepted by the Engineer, seeding, fertilizing, and mulching operations shall be performed as specified in Section 8-01 of the Standard Specifications and Section 8-01 of these special provisions.

8-34.3 Measurement

Measurement of the erosion control matting will be by the square yard of surface area covered and accepted in accordance with these special provisions and the Plans. Required panel overlaps will not be measured for payment.

Measurement for seeding, fertilizing, and mulching will be as outlined in Section 8-01.4 of these special provisions.

8-34.4 Payment

The unit price per square yard for "Erosion Control Matting" shall be full pay to install erosion control matting and to maintain the matting throughout the erosion control period.

Payment for seeding, fertilizing, and mulching will be as outlined in Section 8-01.5 of these special provisions.

8-35 LINER BALLAST WINDSOCK - Add the following new section:

This work shall consist of furnishing, filling, and installing liner ballast windsocks over the liner components to prevent wind uplift until the cell is backfilled, in accordance with these special provisions and as detailed on the Plans.

8-35.1 Materials

The windsock tubing shall consist of used fire hose or other approved tubing. The tubing shall have a cross-sectional area of at least 0.136 square feet (5-inch diameter). The moist sand mixture inside the tube shall provide a ballast weight of at least 15.6 pounds per foot.

The sandbags shall consist of a reinforced polyethylene bag, when filled with a coarse sand and gravel, weighs approximately 90 to 125 pounds. The open end of the bag shall be closed and tied with a nylon or poly cord.

The fill material to be placed in the tubing and sandbags shall consist of a mixture of sand and gravel having a loose unit weight of approximately 115 pounds per cubic foot. Processed source area soils may be used upon approval of the Engineer.

8-35.2 Construction Requirements

The windsock shall extend from the anchor trench at the top of the cell down to the toe of the slope. The maximum slope length is approximately 200 feet.

The tubing shall be completely filled using a grout or concrete pump capable of pumping a moist sand mixture and anchored in the liner system anchor trench. The bottom of the windsock shall be secured with a minimum of two sandbags as detailed on the Plans.

8-35.3 Measurement and Payment

Measurement will be made by the number of windsocks installed, per each.

Payment will be made for "Liner Ballast Windsock", per each. Such price shall be full compensation for furnishing all materials, labor, tools, equipment, and other incidental work necessary to complete the work.

8-36 REINFORCED CHANNEL LINING - Add the following new section:

This work shall consist of installing reinforced channel lining in erosion control ditches in accordance with these special provisions and as detailed on the Plans and in conformity with the lines and dimensions established by the Engineer.

8-36.1 Materials

Materials shall meet the requirements of the following sections:

Reinforced Channel Lining	9-14.5(5)	(SP)
Seed	9-14.2	(SP)
Fertilizer	9-14.3	(SP)

8-36.2 Construction Requirements

All ditch surfaces to be treated, shall be shaped to the specified finished grades and cross-section and finished to a smooth and even condition, and shall be free of undesirable weed or plant growth and all clods, rocks, and debris 3 inches or larger in any dimension. The top 1/2 to 1 inch of soil surface shall be loosened to accommodate seed and lining bedding. Seed and fertilizer shall be applied prior to placement of the lining.

The reinforced channel lining shall be installed in accordance with the manufacturer's instructions. Panels will be anchored at the top of the ditch slope in a minimum 6 inch deep by 6 inch wide trench and stapled. Lining shall be rolled down the channel. The bottom of the panel shall be incorporated as part of any surface water control system required around the base of the slope. The outside edge of the panels shall be terminated in a minimum 6 inch deep by 6 inch wide trench and stapled.

Adjacent panels shall be installed end over end (shingle style) with a 6 inch overlap and stapled in a double row of staggered staples 4 inches apart.

8-36.3 Measurement

Measurement of the reinforced channel lining will be by the square yard of surface area covered and accepted in accordance with these special provisions and the Plans. Required lining overlaps will not be measured for payment.

Measurement for seeding and fertilizing will be as outlined in Section 8-01.4 of these special provisions.

8-36.4 Payment

The unit price per square yard for "Reinforced Channel Lining" shall be full pay to provide and install erosion control channel lining.

Payment for seeding and fertilizing will be made as outlined in Section 8-01.5 of these special provisions.

8-37 PRECAST CONCRETE BLOCKS - Add the following new section:

8-37.1 Description

The work consists of furnishing and installing precast concrete blocks along the outside shoulder of the temporary construction access road as shown on the Plans or as directed by the Engineer.

8-37.2 Materials

The precast concrete blocks shall be nominal 2'x 2'x 6', with lifting loops, as manufactured by Lone Star Northwest, Tacoma, Washington, or an approved equal.

8-37.3 Construction Requirements

The blocks shall be placed with a maximum 5 foot separation.

8-37.4 Measurement and Payment

Measurement will be made by the number of 2'x 2'x 6' blocks, per each, in place.

Payment will be made for "Precast Concrete Block", per each. Such price shall be full compensation for furnishing all materials, labor, tools, equipment, and other incidental work necessary to complete the work.

8-38 CONSTRUCT ACCESS ROAD INTO CELL - Add the following:

8-38.1 Description

The work consists of furnishing, filling, and installing polypropylene duffel top bags in the construction of the temporary construction access road into the OCF cell as shown on the Plans or as directed by the Engineer.

The work also includes furnishing and installing geogrids as shown on the Plans or as directed by the Engineer.

8-38.1 Materials

Materials shall meet the requirement of the following:

Supersacks	9-38	(SP)
Geogrids	9-39	(SP)

8-38.3 Construction Requirements

The supersacks shall be completely filled with processed source area soils or other materials approved by the Engineer. The top of the bag shall be closed and tied off in accordance with the manufacturer's instructions.

Placement of the bags shall require the use of overhead crane systems. Bags shall be initially placed within the bottom of the cell, snugly against previously placed bags and proceeding up the slope of the cell as directed by the Engineer.

After all bags have been installed within the noted limits, placement of additional source area soils and the geogrids shall begin. Placement of the 6 inch lift between the bags and the geogrids shall start at the bottom of the road and proceed upward. This material shall be placed with overhead crane systems. No equipment will be allowed to come in direct contact with the bags.

After the geogrids have been installed in accordance with the manufacturer's instructions, the construction of the remaining roadway prism, and the placement of the surfacing course and precast concrete blocks can take place. The remaining roadway prism material shall be placed starting at the bottom and proceed up the slope.

The access road into the cell shall remain in place during the backfilling of the cell. The precast concrete blocks shall be removed from the road as backfilling operations proceed.

8-38.4 Measurement

Supersacks will be measured, per each, in place.

The geogrid will be measured by the square yard of material placed and accepted within the limits shown.

8-38.5 Payment

Payment will be made for "Supersack", per each. Such price shall be full compensation for furnishing all materials, labors, tools, equipment, and other incidental work necessary to complete the work.

The price per square yard for "Geogrid" shall be full pay to furnish and install geogrids.

DIVISION 9

MATERIALS

9-05 DRAINAGE STRUCTURES, CULVERTS, AND CONDUITS

9-05.21 High Density Polyethylene (HDPE) Pipe - Add the following new section:

9-05.21(1) Acceptable Manufacturers

1. High Density Polyethylene (HDPE) pipe and appurtenances shall be: Driscopipe 1000 as manufactured by Phillips Driscopipe, Inc., P. O. Box 83-3866, 2929 North Central Expressway, Suite 300, Richardson, TX 75083, Telephone 1-800-527-0662; or approved equal.
2. Any HDPE pipe manufacturer who produces PE pipe and fittings in compliance with this special provision shall submit its data sheet, test designations, and the test results, to the Engineer for review and evaluation. Consideration of the documentation will be used to approve the material for inclusion in the work.
3. Pipe and fittings shall be of the size and lengths shown on the Plans.
4. Slots in the pipe shall be as shown on the Plans.

9-05.21(2) Description of Materials

The pipe shall be a PE 3048 high density, high extra molecular weight polyethylene piping system meeting the physical properties and pipe performance requirements listed in Table 9-05-1. It shall be specified by ASTM D-3350 as having a cell classification of PE:345434C. Dimensions and workmanship are specified by ASTM F-714.

9-05.21(3) Pipe Extrusion

The pipe shall be extruded using a melt homogenizing/plasticating extruder and "appropriate" die. The extruder screw design should be customized for the HDPE being processed to minimize melt fracture of the molecular structure thus reducing the molecular weight and changing some physical properties from resin to pipe. The resin should be processed at its melt temperature of 375°F to 425°F. The extruded tubular melt will be vacuum or pressure sized in downstream cooling tanks to form round pipe to specification diameter and wall thickness with a "matte-finish" surface.

TABLE 9-05-1 TYPICAL PHYSICAL PROPERTIES*

Property	Specification	Units	Nominal Values
Material Designation	PPI/ASTM	-	PE 3408
Material Classification	ASTM D-3350	-	III C 5 P34
Cell Classification	ASTM D-3350	0	345434C
Density (3)	ASTM D-1505	gm/cm ³	0.955 max.
Melt Flow (4)	ASTM D-1238	gm/10 min.	<0.15
Flex Modulus (5)	ASTM D-790	Psi	110,000 to 160,000
Tensile Stress.(4)	ASTM D-638	Psi	3000 to 3500
ESCR (3)	ASTM D-1693	F ₀ , Hr.	F ₀ > 5000
HDB @ 73°F (4)	ASTM D-2837	Psi	1600
U-V Stabilizer (C)	ASTM D-1603	%C	≥2
Hardness	ASTM D-2240	Shore "D"	65
Tensile Strength @ Yield (Type IV Spec.)	ASTM D-638 (2"/min.)	Psi	3200
Tensile Strength @ Break (Type IV Spec.)	ASTM D-638	Psi	5000
Elongation @ Break	ASTM D-638	%, minimum	750
Modulus of Elasticity	ASTM D-638	Psi	130,000
ESCR:			
(Cond A, B, C: Mold. Slab)	ASTM D-1693	F ₀ , Hr.	F ₀ > 5000**
(Compressed Ring (Pipe))	ASTM F-1248	F ₀ , Hr.	F ₀ > 3500
Impact Strength (IZOD) (.125" THK)	ASTM D-256 (Method A)	In-lb./in Notch	42
Linear Thermal Expansion Coefficient.	ASTM D-696	in/in/°F	1.2 X 10 ⁻⁴
Thermal Conductivity	ASTM C-177	BTU-in/ Ft ² /hr./°F	2.7
Brittleness Temp.	ASTM D-746	°F	<-180°F
Vicat Soft. Temp.	ASTM D-1525	°F	+257
Heat Fusion Cond.	-	psi @ °F	75 @ 400 °F
NSF Listing	Standard #14	-	"Listed"

* This list of Typical Physical Properties is intended for basic characterization of the pipe.

** Tests were discontinued because no failures and no indication of stress crack initiation.

9-05.21(4) Pipe and Fittings

9-05.21(4)1 Pipe:

1. The pipe and fittings supplied under this specification shall be of the diameter, Standard Dimension Ratio (SDR) , and nominal psi rated, as shown on the Plans.
2. The pipe shall be inspected per industry accepted manufacturer standards for:

a) Diameter

- b) Wall Thickness
 - c) Concentricity
 - d) Quick Burst Pressure and Ductility
 - e) Joint Length
 - f) Straightness
 - g) Quality
 - h) Toe-In
 - i) Overall Workmanship Inspection on ID & OD
 - j) Print Line
3. The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. The pipe shall be homogenous throughout and free of visible cracks, holes, voids, foreign inclusions, or other deleterious defects, and shall be identical in color, density, melt index and other physical properties throughout.
4. Pipe Performance - The pipe shall be in compliance with the physical and performance requirements of Typical Physical Properties of this specification. Specifically, the pipe will be extruded from resin meeting specifications of ASTM D-3350 with a cell classification of PE:345434C; and ASTM D-1248 pipe grade resin type III, Class C, Category 5, grade P34 polyethylene compound. The pipe shall exhibit the short term tensile and compressive physical properties listed in Typical Physical Properties. The pipe shall provide the long term endurance characteristics recognized by: the compressed pipe ring environmental stress crack resistance greater than 1000 hours; the slow crack growth resistance greater than 32 days; and the impact strength (toughness) greater than 42 inch-pound/inch notch.

9-05.21(4)2 Fittings:

The standard HDPE fittings shall be standard commercial products manufactured by injection molding or by extrusion and machining, or, shall be fabricated from PE pipe conforming to this specification. The fittings shall be fully pressure rated by the manufacturer to provide a working pressure equal to the pipe for 50 years service at 73.4°F with an included 2:1 safety factor. The fittings shall be manufactured from the same resin type, grade, and cell classification as the pipe itself. The manufacture of the fittings shall be in accordance with good commercial practice to provide fittings homogeneous throughout and free from cracks, holes, foreign inclusions, voids, or other injurious defects. The fitting shall be as uniform as commercially practicable in color, opacity, density and other physical properties. The minimum "quick-burst" strength of the fittings shall not be less than that of the pipe with which the fitting is to be used.

9-05.21(5) Construction Requirements

Construction and installation shall be performed in compliance with the manufacturer's System Design Guidelines and System Installation Guidelines, and this special provision.

In the event of conflict, the more stringent procedure shall apply unless approved otherwise by the Engineer and EPA.

9-05.21(5)1 Joining:

1. Sections of polyethylene pipe shall be joined into continuous lengths on the jobsite above ground. The joining method shall be the butt fusion method and shall be performed in strict conformance with the pipe manufacturer's recommendations. The butt fusion equipment used in the joining procedures shall be capable of meeting all conditions recommended by the pipe manufacturer, including but not limited to, temperature requirements of 400 OF, alignment, and 75 psi interfacial fusion pressure.
2. Butt fusion shall be 100% efficient offering a joint weld strength equal to or greater than the tensile strength of the pipe. Socket fusion shall not be used. Extrusion welding or hot gas welding of HDPE shall not be used for pressure pipe applications nor in fabrications where shear or structural strength is important.

9-05.21(5)2 Pipe Placement:

1. The pipe shall be placed in the trench in a "snaked" fashion to allow for possible longitudinal expansion and contraction, and shall be allowed to equalize with the ground temperature as much as practical before placing backfill.
2. Bedding for the pipe shall support the pipe uniformly throughout its length and the cradle must be shaped to conform to the outside of the pipe. It is anticipated that the construction of the cradle will require hand tools and manual labor.
3. No pipe shall be laid until the foundation has been approved by the Engineer. All pipe laid without prior approval shall be removed and relaid on an approved foundation at no additional cost to the Owner.

9-05.22 - Geocomposite Slope Drain - Add the following new section:

9-05.22(1) Acceptable Manufacturers

1. Geocomposite drains and fittings shall be: AdvanEDGE pipe as manufactured by Advanced Drainage Systems, Inc., 3300 Riverside Drive, Columbus, OH 43221, Telephone 1-800-821-6710; or approved equal.
2. Any pipe manufacturer who produces pipe and fittings in compliance with this special provision shall submit its data sheet, test designations, and the test results, to the Engineer for review and evaluation. Consideration of the documentation will be used to approve the material for inclusion in the work.
3. Pipe and fittings shall be of the size and lengths shown on the Plans.

9-05.22(2) Description of Materials

The geocomposite drain shall consist of a panel, a minimum of 12 inches wide, with a thickness adequate to meet the specified flow capacity. The panels shall be available in roll lengths to accommodate the maximum project slope lengths without fittings, and containing a non-collapsible waterway for unrestricted flow.

The core material shall be made of polyethylene, polystyrene, or other polymeric material that maintains the required flow under specific loads.

The water inlet area shall be a minimum of 5 square inches open area to the core per lineal foot of drain.

The flow capacity, as determined by ASTM D-4716, shall be 0.736 gallons per minute per foot of width under normal load of 10,000 pounds per square foot and a gradient of 0.1 foot per foot.

The geotextile wrap around the core shall meet or exceed the following:

1. Fabric Weight (ASTM D-5216) - 7.1 ounces per square yard
2. Grab Tensile Strength (ASTM D-4632) - 205 pounds
3. Grab Tensile Elongation (ASTM D-4632) - 50 percent
4. Puncture Resistance (ASTM D-4833) - 95 pounds
5. Permittivity (ASTM D-4491) - 95 gallons per minute per square foot
6. Apparent Opening Size (AOS) (ASTM D-4751) - 100 sieve size

9-13 RIPRAP, QUARRY SPALLS, SLOPE PROTECTION, AND ROCK WALLS

9-13.6 Quarry Spalls - Delete and replace with the following:

The stone shall be hard, sound, and durable. It shall be free from segregation, seams, cracks, and other defects tending to destroy its resistance to weather.

Quarry spalls shall meet the following requirements for grading:

<u>Sieve Size</u>	<u>Percent Passing</u>
8"	100
3"	40 max.
3/4"	10 max.

9-14 EROSION CONTROL AND ROADSIDE PLANTING

9-14.2 Seed - Add the following:

Seed for all slopes shall be grass seed of the following composition, proportion and quality, applied at the rate of 80 pounds per acre on all areas requiring seeding within the project:

<u>Kind and Variety of Seed in Mixture</u>	<u>% by Weight</u>	<u>Minimum % Pure Seed</u>	<u>Minimum % Germination</u>
Chewing Fescue	40	39.20	90
Colonial Bentgrass			
Var. Astoria	10	9.80	85
Perennial Rye	40	39.20	90
White Dutch Clover			
Preinoculated	10	9.80	90
Weed Seed		0.50 max.	
Inert and Other Crop		1.50 max.	
TOTAL		100%	

9-14.3 Fertilizer - Add the following:

The Contractor shall apply sufficient quantities of fertilizer to supply the following amounts of nutrients:

Total Nitrogen as N - 135 pounds per acre.

Available Phosphoric Acid as P_2O_5 - 60 pounds per acre.

Soluble Potash as K_2O - 60 pounds per acre.

Ninety five (95) pounds of nitrogen applied per acre shall be derived from ureaform or ureaformaldehyde. The remainder may be derived from any source.

The fertilizer formulation and application rate shall be approved by the Engineer before use.

9-14.4(2) Wood Cellulose Fiber - Add the following:

Mulch

Mulch shall be a bonded fiber matrix, such as Soil Guard, manufactured by Weyerhaeuser Engineered Fiber Products, 7001 396th SE, Snoqualmie, WA 98065, Telephone 1-800-704-2278, or an approved equal.

Mulch shall be applied at a rate of three thousand (3,000) pounds per acre.

9-14.5(4) Erosion Control Matting

Erosion control matting shall consist of a three-dimensional geomatrix of heavy nylon monofilaments fused at their intersections, such as Enkamat, manufactured by Akzo Nobel Geosynthetics Co., P.O.Box 1057, Enka, NC 28728, Telephone 704-665-5050, or an approved equal.

9-14.5(4)1 Description of Materials

Matting shall be three-dimensional geomatrix of heavy nylon monofilaments fused at their intersection. Ninety-seven (97%) of the geomatrix shall be open space available for soil and root interaction with the filaments.

Matting will have three-dimensional stability without laminated or stitched layers. Matting must also meet specific dimensions and physical properties listed in Table 9-14-1.

TABLE 9-14-1 TYPICAL PHYSICAL PROPERTIES AND DIMENSIONS

ENKAMAT	7020
Dimensions	
Weight oz/yd 2 (g/m2)	12.0 (407)
Weight oz/yd 2 (g/m2) MARV	11.0 (373)
Thickness inches (mm)	.7 (17.8)
Width inches (cm)	39 (99)
Roll Length feet (m)	277 (84.5)
Area yd 2 /roll (m2/roll)	100 (83.6)
Roll Gross Weight lbs. (kg)	77 (34.9)
ENKAMAT	7020
Typical Physical Properties	
Tensile Strength - Length lbs/ft (kN/m)	240 (3.5)
Tensile Strength - Width lbs/ft (kN/m)	125 (1.82)
Tensile Elongation - Length (%)	75
Tensile Elongation - Width (%)	60
Area Holding Capacity inch 3/yd 2 (cm3/m2)	862 (16895)
Max. Shear Resistance lbs/Ft 2 (kN/m2)	8 (39.1)

9-14.5(5) Reinforced Channel Lining

Reinforced channel lining shall consist of a 100% recycled nylon fiber matrix sewn between an extra heavy, UV stabilized top net and a heavy, UV stabilized bottom net, such as P300, manufactured by North American Green, 14649 Highway 41 North, Evansville, IN 47711, Telephone 812-867-6632NC 28728, or an approved equal.

9-14.5(5)1 Description of Materials

Reinforced channel lining shall consist of 100% recycled nylon 6.6 fiber sewn between a black UV stabilized 1/2 inch mesh polypropylene netting on top (5 lbs./ 1000 sq.ft.) and a black UV stabilized 5/8 inch mesh polypropylene netting on the bottom (3 lbs./1000 sq.ft.) with polyester thread.

The lining shall be resistant to photo and chemical degradation. The lining material must also meet specific dimensions and physical properties listed in Table 9-14-2.

TABLE 9-14-2 TYPICAL PHYSICAL AND SUPPLEMENTAL SPECIFICATIONS

Physical Specifications (Roll)			
Width	Length	Weight	Area
6.5 Feet (2m)	83.5 feet (25.4m)	48 lbs \pm 10% (21.8 kg)	60 sq yd (50m ²)
Supplemental Specification Property	Lab Method	Value	Units
Ground Cover	Image Analysis	93	%
Thickness	ASTM D1777	.235	in
Porosity	Calculated	94	%
Resiliency	100 PSI - 3 Cycles	90	%
Mass per unit area	ASTM D3776	12.8	oz/y ²
Tensile Strength	ASTM D4632	37.7	lbs
Elongation	ASTM D4632	31.0	%
Tensile Strength	ASTM D4595	273.6	lbs/ft
Elongation	ASTM D4595	24	%
Tensile Strength	ASTM D1682	156.3	lbs/ft
Flexibility	ASTM D1388-64	23,695	mg-cm
UV Resistance			
Tensile Strength Retained After UV/Water Exposure	ASTM D4355/D1682 ¹	96.9	%
Elongation	ASTM D4355/D1682 ¹	94.1	%

¹ ASTM D1682 used to measure initial and remaining material tensile strengths and elongation.

9-33 CONSTRUCTION GEOTEXTILE - Add the following new sections and property requirements:

9-33.1(1) Cushion Geotextile - Add the following new section:

The cushion geotextile shall be composed of needle punched fibers. Fibers used in the manufacture of the geotextile shall consist of a material composed of at least 85 percent by weight polyolefins, polyesters, or polyamides. The cushion geotextile shall meet the properties listed in Table 9-33-1

The geotextile and threads used in sewing the geotextile shall be chemically resistant to commonly encountered hazardous waste leachate, rot and mildew. The geotextile and threads used in sewing the geotextile shall also contain stabilizers or inhibitors to limit degradation due to ultraviolet (UV) light exposure. Polymeric thread used for sewing shall exhibit chemical and UV resistance equal to or exceeding that of the geotextile.

TABLE 9-33-1 GEOTEXTILE CUSHION PROPERTIES

Property	Units	Specified Value	Test Method
Unit Weight	OZ./S.Y.	16	ASTM D-3776
Tensile Strength (pounds)	LBS.	275	ASTM D-4632
Sewn Seam Tensile Strength	LBS.	138	ASTM D-4632
Puncture Strength	LBS.	185	ASTM D-4833
Mullen Burst Strength	PSI	590	ASTM D-3786
Trapezoidal Tear Strength	LBS.	115	ASTM D-4533
Ultraviolet Stability	%	70	ASTM D-4355

Notes:

1. All numerical values represent minimum average roll values (i.e., average of test results from any sampled roll in a lot shall meet or exceed the minimum average roll values in the table) in weaker principal direction. Lot sampled according to ASTM D-4354, "Practice for Sampling Geosynthetics for Testing."

2. Minimum seam strength when sewn seams are required. Property is not applicable to overlapped seams.

3. Wide Width Test (ASTM D 4595) will not be required for the cushion geotextile application.

9-33.1(2) Geocomposite Drainage Net - Add the following new section:

The geocomposite drainage net shall consist of a polyethylene net mesh specifically fabricated for use as a drainage medium, heat bonded to a 6 oz. nonwoven geotextile fabric on both sides. Minimum physical properties shall be as follows:

TABLE 9-33-3 GEOCOMPOSITE DRAINAGE NET PROPERTIES

<u>Geocomposite Properties</u>	<u>Minimum Average Values</u>	<u>ASTM Standards</u>
Transmissivity @ 1,000 psf, m ² /sec	1 x 10 ⁻³	ASTM D-4716
Transmissivity @ 10,000 psf, m ² /sec	5 x 10 ⁻⁴	
<u>Geonet Properties</u>	<u>Average Values</u>	<u>ASTM Standard</u>
Thickness, mil	200	ASTM D-5199
Density, g/cm ³	0.94	ASTM D-1505
Tensile Strength (MD), lb/in	45	ASTM D-5034/5035
Carbon Black Content, %	2.0	ASTM D-1603/4218
Crush Strength, psi	>50	ASTM D-1621
<u>Geotextile Properties</u>	<u>Minimum Average Values</u>	<u>ASTM Standard</u>
Structure	Nonwoven	
Apparent Opening Size (AOS)	< 0.3 mm	ASTM D-4751
Flow Rate, gpm/ft ²	95	ASTM D-4491
Grab Tensile, lb	205 lbs	ASTM D-4632
Puncture Strength, lb	95 lbs	ASTM D-4833

Typically, the geonet and geotextile are purchased as a geocomposite where the geotextile is bonded to one side of the geonet during the manufacturing process. The advantage of a geocomposite is ease of installation and better quality control during construction. The tables above list the minimum specifications for the geonet and geotextile.

The materials supplied under these special provisions shall be first quality products designed and manufactured specifically for the purposes of this work and which have been satisfactorily demonstrated by prior use to be suitable and durable for such purposes. The materials shall be compounded of high quality ingredients to produce flexible durable membranes. All ingredients shall be well dispersed through the compound prior to being formed into membranes. No water soluble ingredients can be used in the compound, nor can the ingredients contain water soluble components.

The resultant membranes shall be free from dirt, oil, foreign matter, creases, tears, holes, or other defects.

9-33.1(3) Geotextile Installation

1. All geotextiles shall be handled in a manner to ensure they are not damaged.
2. On slopes, the geotextiles shall be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geotextile sheet in sufficient tension to preclude folds and wrinkles.
3. In the presence of wind, all geotextiles shall be weighted with sand bags or equivalent.
4. Geotextiles shall be cut using an approved cutter. If the material is being cut in place, special care must be taken to protect other geosynthetic materials from damage.

5. Care shall be taken not to entrap stores or excessive dust that could damage the geomembrane, or generate clogging of drains or filters.
6. Seams shall be overlapped at least 12 inches.
7. Repairs - Any holes or tears in the geotextile shall be repaired as follows:
 - a) On slopes - A patch made from the same geotextile shall be seamed into place. Should any tear exceed 10% of the width of the roll, that roll shall be removed from the slope and replaced.
 - b) Horizontal areas - A patch made from the same geotextile shall be spot-seamed in place with a minimum of twelve inches (12") overlap in all directions.
8. During geotextile placement, the QA personnel shall verify the following:
 - a) The geotextile is cut only with an approved cutter, and is not torn or ripped.
 - b) The thread used to sew the panels together meets specification requirements.
 - c) The panels are being joined in accordance with the Plans and Specifications.
 - d) Any roll of geotextile with a tear exceeding ten (10) percent of the roll width is removed and replaced.

9-33.2 Geotextile Properties - Add wide width test properties to Tables 1 and 3 (WSDOT 9-33.2) and modify properties in Table 3 (WSDOT 9-33.2):

Table 1
Geotextile for underground drainage strength properties for survivability

Geotextile Property	Test Method	Low Survivability Woven/Nonwoven	Moderate Survivability Woven/Nonwoven
Wide Width Tensile Ultimate, Machine Direction 6oz/yd ² 12oz/yd ²	ASTM D 4595	70/30 P/in min 150/80 P/in min	90/35 P/in min 180/85 P/in min

Table 3
Geotextile for separation or soil stabilization

Geotextile Property	Test Method	Separation Woven/Nonwoven	Soil Stabilization Woven/Nonwoven
AOS for LCRS	ASTM D4751	0.85 mm max (#20 U.S. Sieve)	-
AOS for LDCRS	ASTM D4751	0.21 mm max (#70 U.S. Sieve)	-
Mullen Burst	ASTM D3786	- / 290 psi min	-/330 psi min
Wide Width Tensile Ultimate, Machine Direction 6oz/yd ² 12oz/yd ²	ASTM D4595	70/30 P/in min 150/80 P/in min	90/35 P/in min 180/85 P/in min

9-34 BENTONITE - Add the following new section:

Bentonite to be mixed with site materials shall be a natural, powdered Wyoming-type sodium bentonite meeting the properties listed in Table 9-34-1. Bentonite shall be a naturally occurring clay composed principally of mineral sodium montmorillonite.

TABLE 9-34-1 BENTONITE PROPERTIES

Property	Test Method	Required Value	Test Frequency
Free Swell	ACC 1010	24 ml/2g min.	60 tons
Filtrate Loss	API 13A/13B	15 ml max.	50 tons
Moisture Content	ACC 1009	10% max.	50 tons
Particle Sizing	ASTM D 422	70% min. - #200	50 tons

9-34.1 Submittals

The Contractor shall submit the following to the Engineer for approval:

1. Identification of the bentonite supplier;
2. List of the physical and chemical properties of the bentonite;
3. A representative sample (10 lbs.) of the bentonite to be supplied; and
4. Manufacturer's Certificate of Compliance verifying the materials to be supplied conform the these Specifications.

9-35 GEOSYNTHETIC LINERS - Add the following new section:

This special provision addresses geomembranes and geosynthetic clay liners.

The Contractor shall provide to the Engineer the names of the manufacturers of all geosynthetic liner materials proposed for inclusion in the work. This includes geomembrane, geosynthetic clay liner (GCL), geocomposite, and cushion geotextile materials proposed for constructing the liner system. These materials shall conform in every respect to these special provisions.

The Contractor shall provide to the Engineer six (6) samples of each liner component material. Each sample shall be 15 inches wide by 15 inches long. The material will be tested for critical interface shear strengths between the various liner components. The interface testing program shall be performed by the Engineer and is described in the Remedial Action Comprehensive Plans and Documents, Addendum A, CQAP for PA 1.0.

The Contractor shall not have materials scheduled for delivery until results of the CQA interface testing program verifies the following residual shear strength values for normal stresses up to 10,000 psf:

- Equal to or greater than 11.5 degrees between the geocomposite and the DST 60 mil HDPE.

- Equal to or greater than 14.5 degrees between the GCL and the geocomposite.
- Equal to or greater than 22 degrees between the DST 60 mil HDPE and the compacted low-permeability soil.

9-35.1 High Density Polyethylene (HDPE) Liner

9-35.1(1) Acceptable Manufacturers

Textured high density polyethylene (HDPE) geomembrane shall be produced from specially formulated, virgin polyethylene resins as manufactured by: GSE Lining Technology, Inc., 19103 Gundle Road, Houston, TX 77073, 1-800-435-2008; Layfield Plastics, Inc., 3890 Hammer Drive, Bellingham, WA 98226, Telephone 1-800-796-6868; National Seal Co., 1245 Corporate Boulevard, Suite 300, Aurora, IL 60504, Telephone 1-800-323-3820; Poly-flex, Inc., 2000 W. Marshall Drive, Grand Prairie, TX 75051, Telephone 1-800-527-3322, or an approved equal.

9-35.1(2) Definitions Used in This Section

1. Alloys, Polymeric: A blend of two or more polymers such as a rubber and a plastic to modify a given property; e.g., tensile strength.
2. Air Lance: A commonly used nondestructive test method performed with a stream of air forced through a nozzle at the end of a hollow metal tube to determine seam continuity and tightness of relatively thin, flexible geomembranes.
3. Adhesive: A chemical system used in the bonding of geomembranes. The adhesive residue results in an additional element in the seamed area. (Manufacturers and fabricators should be consulted for the various types of adhesives used with specific geomembranes.)
4. Batch: A quantity of resin, usually the capacity of one railcar, used in the fabrication of high density polyethylene geomembrane roll. The finished roll will be identified by a roll number corresponding to the resin batch used.
5. Bodied Chemical Fusion Agent: A chemical fluid containing a portion of the parent geomembrane that, after application of pressure and after the passage of time, results in the chemical fusion of two essentially similar geomembrane sheet, leaving behind only that portion of the parent material.
6. Bridging: Condition existing when the geosynthetic is not in contact with the underlying material.
7. Chlorinated Polyethylene (CPE): Family of polymers produced by the chemical reaction of chlorine with polyethylene. The resultant polymers presently contain 25-45% chlorine by weight and 0-25% crystallinity. CPE will be used to designate thermoplastic liners, CM will be used to designate vulcanized liners.
8. Contractor: The person, firm or corporation with whom Owner has entered into the Agreement.
9. CPER: Same product as CPE but with a polyester reinforcement (scrim) built into the construction to give additional strength and stability.

10. Chlorosulfonated Polyethylene (CSPE): Family of polymers produced by the reaction of polyethylene with chlorine and sulfur dioxide. Present polymers contain 25-43% chlorine and 1.0-1.4% sulfur.
11. Chemical Fusion: The chemically-induced reorganization in the polymeric structure of the surface of a polymer geomembrane that, after the application of pressure and the passage of time, results in the chemical fusion of two essentially similar geomembrane sheets being permanently joined together.
12. Construction Quality Assurance (CQA): A planned system of activities whose purpose is to provide an evaluation of the completed liner and initiate corrective action where necessary.
13. Construction Quality Control: Actions that provide a means of monitoring and measuring the quality of the product as it is being installed.
14. CQA Monitor: Owner's representative responsible for observing and documenting activities related to quality assurance during construction.
15. Curing: The strength gain over time of a chemically fused, bodied chemically fused, or chemical adhesive geomembrane seam due primarily to evaporation of solvents or crosslinking of the organic phase of the mixture.
16. Destructive Tests: Tests performed on geomembrane samples cut out of a field installation or test strip to verify specifications performance requirements, e.g., shear and peel tests of geomembrane seams during which the specimens are destroyed.
17. Environmental Stress Crack (ESC): External or internal stress propagation in a plastic caused by environmental conditions which are usually chemical or thermal in nature.
18. Extrudate: Geosynthetic material produced in the form of a rod to be used by the Installer to extrusion weld panels of geomembrane together.
19. Fabricator: An individual, firm or corporation that fabricates geomembrane liner panels from geomembrane roll goods.
20. Factory Seams: The seaming of geomembrane rolls together in a factory to make large panels to reduce the number of field seams
21. Field Seams: The seaming of geomembrane rolls or panels together in the field making a continuous liner system.
22. Flexible Membrane Liner (FML): Synonymous term for geomembrane.
23. Flood Coating: The generous application of a bodied chemical compound, or chemical adhesive compound to protect exposed yarns in scrim reinforced geomembranes.
24. Geomembrane: An essentially impermeable synthetic membrane used as a solid or liquid barrier. Synonymous term for flexible membrane liner (FML).
25. Geomembrane Subsurface: Material surface upon which geomembrane will be placed.
26. Geosynthetics: Products manufactured from polymeric material to be used with geotechnical engineering-related materials as an integral part of civil engineering works. Geosynthetics include geomembranes, geotextiles, geocomposites, and HDPE pipe.
27. Geosynthetic Quality Assurance Laboratory (Third Party Laboratory): The party, independent from the Owner, Manufacturer, and Installer, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site.

28. Geotextile: Any permeable textile used with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project, structure, or system.
29. Gun: Synonymous term for hand held hot air device.
30. Installer: An individual, firm or corporation that installs fabricated geomembrane liner panels and/or roll goods and field seams them into a complete geomembrane liner system.
31. Manufacturer: An individual, firm or corporation that produces sheet or roll geomembrane from resins stabilizers, and other additives.
32. Nondestructive Test: A test method which does not require the removal of samples from, nor damage to, the installed liner system. The evaluation is done in an in-situ manner. The results do not indicate the seam's mechanical strength. Typical nondestructive tests are air-lance and vacuum box methods.
33. Panel: The unit area of geomembrane, a roll or a portion of a roll, that will be seamed in the field.
34. Panel Layout Drawings: Drawings submitted by the Installer showing a tentative panel layout indicating panel numbers, field seams and details.
35. Plasticizer: A material, generally an organic liquid, incorporated in a plastic or rubber formulation to soften the resin polymer and improve flexibility, ductility and extensibility.
36. Polyethylene: A semi-crystalline thermoplastic polymer composition prepared from polymerized ethylene monomer(s) and stabilizers such as antioxidants and pigmentation. Membranes can be manufactured from High Density Polyethylene (HDPE), Very Low Density Polyethylene (VLDPE), or both, and can incorporate specialty surfacings such as texturing, reflective coloration, or electrically conductive laminations as specified.
37. Polymer: A carbon based organic chemical material formed by the chemical reaction of monomers having either the same or different chemical structures.
38. Polyvinyl Chloride (PVC): A non-crystalline thermoplastic polymer composition prepared from polymerized vinyl monomer by blending with one or more low or non-volatile plastisizers made by polymerizing vinyl chloride monomer.
39. Scrim Designation: The weight and number of yarns of fabric reinforcement per inch of length and width, e.g., a 10 X 10 scrim has 10 yarns per inch in both the machine and cross machine direction.
40. Sealant: A viscous chemical used to seal the exposed edges of scrim reinforced geomembranes. (Manufacturers and installers should be consulted for the various types of sealant used with specific membranes).
41. Seaming Boards: Smooth wooden boards (preferably 1" X 12" X 8', or more), placed beneath the area to be seamed to provide a uniform surface to applied roller pressure in the fabrication of field seams.
42. Subcontractor: An individual, firm or corporation having a direct contract with Contractor or with any other subcontractor for the performance of a part of the work at the site.
43. Tensiometer: A device containing a set of opposing grips used to place a geomembrane seam in tension for evaluating its strength in shear or in peel.

44. Test Strips: Trial sections of seamed geomembranes used to establish methods and materials for chemical and chemical adhesive seams under a specific set of atmospheric conditions.
45. Thermal Fusion: The temporary, thermally-induced reorganization in the polymeric make-up of the surface of a polymer geomembrane that, after the application of pressure and the passage of a certain amount of time, results in the two geomembranes being permanently joined together.
46. Vacuum Box: A nondestructive test method which develops a vacuum in a localized region of a geomembrane seam in order to evaluate the seam's tightness and suitability.
47. Wicking: The phenomenon of liquid transmission within the fabric yarns of reinforced geomembranes via capillary action.

9-35.1(3) Quality Assurance

1. Company qualifications:
 - a. The installation company shall have worked in a similar capacity on at least 5 projects similar in complexity to this project with each project involving at least 500,000 square feet of a similar polyethylene product.
 - b. The installation company shall have installed a minimum of 10 million square feet of polyethylene geomembrane.
2. Personnel qualifications:
 - a. Installation supervisor/field engineer shall have worked in a similar capacity on at least 2 jobs similar in size and complexity to this project.
 - b. The master seamer shall have completed a minimum of 5,000,000 square feet of geomembrane seaming work using the type of seaming apparatus proposed for use on this project.
 - c. Other seamers shall have seamed a minimum of 1,000,000 square feet of geomembrane.
3. Manufacturer Source Quality Control.

The manufacturer shall perform the quality control tests listed in Table 9-35-1 at the manufacturing plant. Quality control certificate shall be provided to the Engineer as specified in Section 9-35.1(4)B of these Special Provisions.
4. Quality Assurance by Owner.

The Owner may engage the services of a Construction Quality Assurance Consultant (CQAC) for monitoring the quality and installation of material. The Contractor shall cooperate fully with supplemental testing performed by the CQAC and shall make available samples required for such testing.
5. Delivery, Storage and Handling
 - a. Deliver geomembrane to the site only after the Engineer receives and approves the required submittals. Damaged or unacceptable material

- shall be immediately removed from the site and replaced at no cost to the Owner.
- b. Space to store the geomembrane rolls or pallets will be designated by the Engineer. Store geomembrane rolls or pallets to protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage. Stack geomembrane no more than 3 rolls or 1 pallet high.
 - c. Use appropriate handling equipment to load, move or deploy geomembrane rolls or panels. Appropriate handling equipment includes cloth chokers and spreader bar for loading, spreader and roll bars for deployment. Do not fold geomembrane material. Geomembrane damaged during handling shall be repaired to the satisfaction of the Engineer. Geomembrane irreparably damaged, as determined by the Engineer, shall be immediately removed from the site and replaced. Repair, removal and replacement shall be solely at the Contractor's expense.
 - d. Upon mobilization to the site the Engineer shall perform the following:
 - 1) Verify the equipment used on site is adequate and does not risk damage to the geomembrane or other materials.
 - 2) Mark rolls or portions of rolls which appear damaged.
 - 3) Ensure that rolls are properly labeled and that labeling corresponds with Quality Control documentation and Shipping Bills of Lading.
6. Warranty
- a. The installer of the geomembrane to be used in the work shall warrant his workmanship to be free of defects for 2 years after final acceptance of the work. This warranty shall include, but not be limited to, all seams, anchor trenches, geomembrane attachments to appurtenances, and penetration seals. The geosynthetic installer shall also obtain and furnish the Owner a warranty from the geomembrane manufacturer for the materials used. The material warranty shall be for defects or failure due to weathering for 10 years, with temperatures ranging from (-) minus 30 degrees Fahrenheit to (+) plus 110 degrees Fahrenheit, after the completion of the work on a prorata basis.
 - b. Should a defect or failure occur within the aforesaid periods, the geosynthetic installer shall bear all costs for repair and/or replacement of the geomembrane and shall in addition bear all costs for the excavation of any cover backfill that is required to be removed in order to repair and/or replace the geomembrane. All materials removed to allow repairs to be made shall be reinstalled by the geosynthetic installer in accordance with these special provisions.

TABLE 9-35-1 MANUFACTURER SOURCE QUALITY CONTROL TESTING

TEST	TEST DESIGNATION	FREQUENCY (See Footnotes)
Sheet Thickness	ASTM D-1593, Para 9.1.3 or ASTM D-5994 (for textured sheets)	20 Per Roll
Oxidation Induction Time of Polyolefins	ASTM D-3895	(5)
Tensile Strength Yield	ASTM D-638	(3)
Tensile Strength Break	ASTM D-638	(3)
Elongation at Break	ASTM D-638	(3)
Elongation at Yield	ASTM D-638	(2)
Tear Resistance	ASTM D-1004, Die C	(3)
Puncture Resistance	ASTM D-4833	(3)
Resistance to Soil Burial	ASTM D-3083, Using ASTM D-638 Type IV	(4)
Dimensional Stability, Each Direction	ASTM D-1204, 212 Degrees Fahrenheit (1 hr)	(1)
Environmental Stress Crack	ASTM D-1693	(5)
Low Temperature Brittleness	ASTM D-746	(4)
Carbon Black Content	ASTM D-1603	(3)
Carbon Black Dispersion	ASTM D-3015	(3)
Footnotes:		
(1) One per 100,000 square feet of sheet produced or one per resin batch, whichever results in the greater number of tests.		
(2) One test on typical sheet and seam. Perform a shear test (ASTM D-638) on a sample obtained from the same sheet and a shear test (ASTM D-4437) on the seam.		
(3) One per 50,000 square feet or one per resin batch, whichever results in the greater number of tests.		
(4) Certification only required.		
(5) One test per resin batch.		

9-35.1(4) Submittals

- A. Two copies of the following documents shall be submitted by the Contractor no later than 3 weeks prior to production of the geomembrane.
1. Complete written instructions for storage, handling, installation and seaming of the geomembrane which are in compliance with these specifications and conditions of warranty.
 2. Panel layout drawings showing both fabricated and field seams, and details not conforming with the Plans (if any).
 3. Qualifications of the geomembrane fabricator shall include:
 - a. Fabrication schedule
 - b. Resume of the master seamer to be assigned to this project, including dates and duration of employment.
 - c. Resume of the Engineer or fabrication supervisor to be assigned to this project, including dates and duration of employment.
 - d. A list of personnel performing factory seaming operations, along with pertinent experience information.

4. Qualification of the geomembrane installer, including:
 - a. A drawing showing the installation panel layout identifying both fabricated (if applicable) and field seams, as well as any variance or additional details which deviate from the engineering drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc.
 - b. Installation schedule.
 - c. Resume of the master seamer to be assigned to this project, including dates and duration of employment.
 - d. Resume of the field engineer installation supervisor to be assigned to this project, including dates and duration of employment.
 5. Installer's Quality Control Manual.
- B. The following documents shall be submitted to the Engineer prior to the shipment of the geomembrane to the Site:
1. Polyethylene Resin Data:
 - a. Statement of production date or dates.
 - b. Laboratory certification that the resin meets specifications.
 - c. Certification that all resin is from the same manufacturer.
 - d. Copy of quality control certificates issued by manufacturer.
 - e. Reports of tests defined in Table 9-35-1 from manufacturer.
 2. Geomembrane roll and extrudate data:
 - a. Statement of production date or dates
 - b. Laboratory certification that the materials meet the specification.
 - c. Copy of quality control certificates issued by the manufacturer.
 - d. Reports of tests defined in Table 9-35-1 from the manufacturer.
 - e. Statement that no reclaimed polymer is added to the resin.
 - f. Certification that the extrudate rod or bead is made of the same resin as the geomembrane.
 3. Manufacturer Source Quality Control test results as specified hereinafter.
- C. Submit the following prior to start of the geomembrane deployment:
1. Equipment list defining field seaming equipment by quantity and type.
 2. List of personnel assigned to perform the seaming operations.
 3. Sample warranties for material and installation as specified hereinafter for review by the Owner.
 4. Certificate of acceptance of prepared subgrade by geomembrane installer for each area to be covered by geomembrane, signed by the installation supervisor.
 5. Anchor trenches excavated in clay soils susceptible to desiccation cracks should be excavated only the distance required for that day's liner placement to minimize the potential of desiccation cracking.

- D. During installation, the Contractor shall submit the following QL documentation prepared by the Contractor during installation as specified hereinafter.
- E. Upon completion of the installation, the Contractor shall submit the following:
 - 1. Certificate stating the geomembrane has been installed in accordance with the Contract Documents.
 - 2. Manufacturer's and Installer's warranties as specified hereinafter.
 - 3. Record drawings showing location of panels, seams, repairs, patches, and destructive samples, including detailed measurements.

9-35.1(5) Materials

9-35.1(5)A Description of Materials

Geomembrane liner shall be first quality product and manufactured specifically for the purposes of this work and shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes. The liner, resin, and extrudate shall be manufactured by one of the acceptable manufactures listed in Section 9-35.1(1).

9-35.1(5)B Physical Characteristics

- 1. Resin - Flexible membrane liner resin shall be new, first quality material compounded and manufactured specifically for the purpose of producing flexible membrane liners. All resins shall be of the same type and no batch shall be blended with recycles or seconds.

Resins shall meet the following specifications:

TABLE 9-35-2 RESIN SPECIFICATIONS

PROPERTY	REQUIREMENT	TEST METHOD
Specific Gravity*	< 0.935	ASTM D-792 Method A or ASTM D-1505
Melt Index	< 0.3 g per 10 minutes	ASTM D-1238 Condition 190/2.16

* Measured prior to adding carbon black, pigments, or other additives.

Above tests shall be performed at a minimum frequency of one (1) per 50,000 square feet or one (1) per resin batch, whichever results in the greater number of tests.

2. Flexible Membrane Liner Roll - The flexible membrane liner roll shall meet the following requirements:
 - a. Processing aids, antioxidants and other additives other than carbon black shall not exceed a combined maximum total of 1 percent by weight.
 - b. Total combined percentage of processing aids, anti-oxidants, carbon black and other additives shall be less than 3.5 percent by weight of finished flexible membrane liner.
 - c. Materials shall be produced in North America.
 - d. Holes, pinholes, bubbles, blisters, gels or undispersed resins and undispersed carbon black in the flexible membrane liner will not be allowed. Nicks and cuts on roll edges will not be allowed.
 - e. Flexible membrane liner shall be supplied in rolls. Folding will not be permitted. Identify each roll with labels indicating thickness, length and width, manufacturer, plant location, and manufacturer's roll identification number.
 - f. Flexible membrane liner shall meet the specifications listed in Table 9-35-2.
3. Extrudate Rod or Bead - Extrudate rod or bead shall be made from the same resin as the flexible membrane liner with carbon black. Additives shall be thoroughly dispersed in the extrudate. Contamination by foreign matter will not be allowed.

TABLE 9-35-3 GEOMEMBRANE SPECIFICATIONS

PROPERTY	VALUE		TEST METHOD
TEXTURED LINERS			
Thickness	40 mil	60 mil	ASTM D5994
Density. g/cc. (Min.)	0.94	0.94	ASTM D1505
Melt Flow Index. g/10 min.	<u><1.0</u>	<u><1.0</u>	ASTM D1238 Condition E
Carbon Black (%) (Min.)	2.0	2.0	ASTM D1603
Tensile Properties (Typical) 1. Tensile Strength at Break lb/in - width 2. Tensile Strength at Yield lb/in - width 3. Elongation at Break (Percent) 4. Elongation at Yield (Percent)	162 86 500 13	243 130 560 13	ASTM D638 Type IV ASTM D638 Type IV ASTM D638 Type IV ASTM D638 Type IV
Tear Resistance Initiation. lbs. (Typical)	30	45	ASTM D1004 Die C
Low Temperature Brittleness. °F (Typical)	-107	-107	ASTM D746 Procedure B
Dimensional Stability. % Change Each direction. (Max.)	±2	±2	ASTM D1204
Resistance to Soil Burial. Percent change in original value. (Typical) Tensile Strength at Break and Yield elongation at Break and Yield	±10 ±10	±10 ±10	ASTM D3083 using ASTM D638 Type IV % Change % Change
Environmental stress Crack. Hours. (Min.)	1500	1500	ASTM D1693
Puncture Resistance. Pounds. (Typical)	52	80	ASTM D4833
Coefficient of Linear Thermal Expansion X10 ⁻⁴ °C ⁻¹ (Typical)	1.2	1.2	ASTM E831
Thermal Stability Oxidative Induction Time (OIT). Minutes. (Min.)	100	100	ASTM D3895 200 ^o C. Pure O ₂ 1ATM

9-35.1(6) Installation**9-35.1(6)A. Subgrade Preparation**

The Contractor shall be responsible for accepting and maintaining the subgrade in a condition suitable for installation of the liner.

1. Prior to deployment of the geomembrane, the geomembrane installer and the Contractor shall inspect the subgrade to ascertain its suitability for installation in compliance with the terms of the product warranty and the requirements of this specification. The Contractor shall submit to the Engineer a certification signed by the Installer and the Contractor stating that the prepared surface is satisfactory. Installation of geomembrane without providing written certification shall constitute acceptance of the subgrade by the Installer and Contractor.
2. Excavate anchor trenches to the lines and widths shown on the Plans. Care shall be taken to ensure that the integrity of the anchor trench excavations remains intact between excavation and liner installation activities. Round edges of anchor trenches as recommended by the geomembrane manufacturer or cushion with geotextiles and backfill. Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetics. The QA personnel shall observe the backfilling operation.

9-35.1(6)B. Geomembrane Installation

1. Panel Marking - Each panel shall be assigned a simple and logical identifying code number or letter. Prior to commencement of liner deployment, the Contractor shall submit layout drawings to indicate the panel configuration and general location of field seams. The Contractor shall submit as-built drawings of the geomembrane identifying codes.
2. Daily Panel Installation - No more panels shall be installed in one day that can be seamed or tack welded during that same day.
3. General - Do not damage geomembrane by handling, traffic, or leakage of hydrocarbons or any other means. Do not wear damaging shoes or engage in activities that could damage the geomembrane. Unroll geomembrane panels using methods that will not damage, stretch or crimp the geomembrane. Prevent excess condensation on the geomembrane such that the underlying surface is not adversely impacted. Protect underlying surface from damage. Provide sufficient material to allow for geomembrane shrinkage and contraction. Use methods that minimize wrinkles between adjacent panels. Place ballast on geomembrane to prevent uplift from wind. Use ballast that will not damage geomembrane. Repair damage to subgrade or other underlying

materials prior to completing deployment of geomembrane. Do not allow vehicle traffic directly on geomembrane. Remove folded material.

Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for testing and/or repair. Any portion of the lining damaged during installation shall be removed or repaired by using an additional piece of the same membrane as specified herein. The liner shall be installed in a relaxed condition and shall be free of stress or tension upon completion of the installation. Stretching the liner to fit is not permissible. Backfill anchor trenches.

4. Weather Considerations - Place and seam geomembrane only when ambient temperatures, measured six inches above the geomembrane, are between 40 degrees F and 100 degrees F, unless otherwise specified or approved. Installation below 40 degrees F shall occur only after verifying that the geomembrane can be seamed according to specifications and approval by the Engineer. Do not install geomembrane during precipitation, in the presence of excessive moisture, in areas of ponded water, or in the presence of excessive winds.

9-35.1(6)C. Pipe and Manhole Boots

Pipes, manholes, and other penetrations of the geomembrane shall be sealed with field fabricated boots as shown on the Plans. The flange portion of the boot shall match the angle of the slope or bottom where the pipe or manhole enters the liner for a smooth fit without excess stretching of the material.

9-35.1(6)D. Seaming

1. Seam Layout - Seam layout shall meet the following requirements:
 - a. Orient seams parallel to line of maximum slope, i.e., orient down, not across, slope.
 - b. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.
 - c. Keep butt seams at least ten (10) feet horizontally away from toe of slope.
 - d. Use seam numbering system compatible with panel numbering system.
2. Master Seamer - At least one Master Seamer meeting the qualifications specified in Section 9-35.1(3)2.b. shall be present during all seaming operations. Additional seamers meeting the qualifications of Section 9-35.1(3)2.c. shall be utilized to avoid delaying work. The Master Seamer shall provide direct supervision over other seamers.
3. Seaming Equipment - Seaming equipment and accessories shall meet the following requirements:
 - a. Seaming apparatus shall be equipped with gauges giving temperatures in apparatus and at nozzle (extruding type).

- b. Seaming apparatus shall use power source capable of providing constant voltage under combined line load.
 - c. Seaming apparatus shall be provided with protective lining and splash pad large enough to catch spilled fuel under electric generator when located on liner.
4. Trial Seaming - Trial seaming shall be accomplished by the Contractor on-site and shall meet the following requirements:
- a. Conduct trial seams on pieces of geomembrane to verify adequate seaming methods and conditions.
 - b. Conduct trial seams:
 - 1) At beginning of each seaming period
 - 2) At least once for each four seaming hours
 - 3) For each seaming apparatus used
 - 4) At least once per shift for each person performing seaming
 - 5) When changes in climatic conditions or other changes could affect seam quality
 - c. Make test seam in the location of seaming and in contact with subgrade or geotextile (same condition as the geomembrane to be seamed.)
 - d. Make test seam sample at least three (3) feet long and eleven (11) inches wide with the seam centered lengthwise.
 - e. Cut two, 1-inch wide test strips from opposite ends of the trial seams.
 - f. Cut specimens constant 1-inch wide and clamp at 90 degree angle in tensiometer.
 - g. Quantitatively test specimens for peel adhesion first, and bonded seam strength (shear) second. Insure that these tests are performed in this order.
 - h. A trial seam sample passes when the following results are achieved for both peel and shear tests. For double-wedge welding, test both welds. In addition, both welds must pass in peel mode.
 - 1) The break is film tearing bond (FTB)
 - 2) The break is ductile
 - 3) The strength of break is:
 - a. 50 pounds per inch (ppi) for peel test (40-mil) and 70 ppi (60-mil)
 - b. 60 ppi for shear test (40-mil) and 100 ppi (60-mil)
 - i. Repeat the trial weld in its entirety if one (1) of the trial seam samples fails in either peel or shear mode.
 - j. When repeated trial seam fails, to not use seaming apparatus and seamer for welding until deficiencies or conditions are corrected and two (2) consecutive successful trial seams are achieved.
5. General Seaming Procedures - The seaming procedure used shall be as follows:
- a. Do not weld on liner until all trial seam test samples made by the equipment to be used passes tests as defined above.
 - b. Clean surface of grease, moisture, dust, dirt, debris or other foreign material.

- c. Overlap panels by a minimum of three (3) inches for extrusion and four (4) inches for hot wedge seaming.
- d. Do not use solvent or adhesive.
- e. Provide adequate material on weld to allow peel testing of both sides of a double wedge seam.
- f. Seaming shall extend to the outside edge of panels to be placed under the anchor berm and in the anchor trench.
- g. If required, a firm substrate shall be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.
- h. If seaming operations are carried out at night, adequate illumination shall be provided.
- i. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is less than three (3) inches shall then be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions.
- j. Seaming documentation - All seaming operations shall be documented by the Quality Control coordinator. Welding technicians will mark on the liner with mean streak permanent markers at the start of all seams information regarding date, time, welding technician ID, machine number, and machine operating temperature and speed. The Quality Control coordinator will record date, time, seam number, technician ID, machine ID, set temperature, speed, and weather conditions.
- k. The following will be logged every two hours:
 - 1) Ambient temperature measured six (6) inches above geomembrane surface.
 - 2) Extrudate temperatures in barrel and at nozzle.
 - 3) Operating temperature of hot wedge.
 - 4) Preheat temperature.
- l. Seam only when ambient temperature, measured six (6) inches above the geomembrane is between 40 degrees F and 100 degrees F unless other limits are accepted, in writing, by the Engineer.
- m. If the Installer wishes to use methods which may allow seaming at ambient temperatures below 40 degrees F (5 degrees C) or above 100 degrees F (40 degrees C), then the Installer must demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced at ambient temperatures between 40 degrees F (5 degrees C) and 100 degrees F (40 degrees C), and that the overall quality of the geomembrane is not adversely affected. In addition, a change order to the contract between the Owner and the Contractor shall be required which specifically states that the seaming procedure does not cause any physical or chemical modification to the geomembrane that will generate any short or long term damage to the geomembrane. Only then will the

temperatures in the above quality assurance procedure be modified accordingly.

6. Extrusion Type of Seaming:
 - a. Purge welding apparatus of heat-degraded extrudate before welding if extruder is stopped.
 - b. Clean seam surfaces of oxidation by disc grinder or equivalent not more than 1/2 hour before extruding seam.
 - c. Tack bond adjacent panels together using procedures that do not damage geomembrane.
 - d. Bevel edges of top geomembrane before extrusion welding.
 - e. Abrade liner surface a maximum of one-quarter (1/4) inch beyond weld bead area.
 - f. Grind ends of all seams when restarting seaming.
 - g. Do not remove more than 5 percent of geomembrane thickness when grinding.
 - h. Grind across, not parallel to, seams.
7. Hot Wedge Seaming - Welding apparatus shall be automated vehicular mounted devices equipped with devices giving applicable temperatures and pressures. Grind edges of cross seams to a smooth incline (top and bottom) prior to welding. Place smooth insulating plate or fabric beneath hot welding apparatus after usage. Protect against moisture build-up between sheets. When welding across previously placed seams, conduct trial seams at least every two hours, otherwise conduct trial seams once prior to start of work and once at mid-shift. Place a patch over the intersection of all seams.
8. During seaming operations the QA personnel shall verify the following:
 - a. The Lining Subcontractor has the number of seamers and spare parts agreed to in the pre-construction meeting.
 - b. Equipment used for seaming will not damage the FML.
 - c. The extruder is purged prior to beginning a seam until all the heat-degraded extrudate is removed (extrusion welding only).
 - d. Seam grinding has been completed less than one hour before seam welding (extrusion welding only).
 - e. The ambient temperature measured six inches above the FML surface is between 40 and 90 degrees Fahrenheit and the relative humidity is less than 80%.
 - f. The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion only).
 - g. The weld is free of dust and other debris.
 - h. For cross seams, the seam is ground to a smooth incline prior to welding.
 - i. The seams are overlapped a minimum of four inches.
 - j. No solvents or adhesives are present in the seam area.
 - k. The procedure used to temporarily hold the panels together does not damage the panels and does not preclude QA testing.

- l. The panels are being seamed in accordance with the Plans and Specifications using the approved and proper equipment with gauges giving applicable temperatures.
- m. There is no free moisture in the weld area.
- n. The electric generator is placed on a smooth base such that no damage occurs to the FML.
- o. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage.
- p. The geomembrane is protected from damage in heavily trafficked areas.
- q. Monitor and log all appropriate temperatures and conditions, and log and report to the QA personnel any non-compliances.

9-35.1(6)E. Defects and Repairs

1. Inspection:

- a. During installation and seaming, all seams and non-seam areas of the geomembrane shall be visually examined for defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of the examination. Areas suspected of deficiencies shall be marked. Areas of geomembrane requiring more than one patch per 5,000 square feet shall be removed and replaced at no additional cost to the Owner.
- b. Each suspect location both in seam and non-seam areas shall be repaired and non-destructively tested. Work shall not proceed with any materials which will cover locations which have been repaired until passing test results are achieved.

2. Repair Procedures:

- a. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test, shall be repaired. The Contractor shall provide a written recommendation for method of repair to the Engineer prior to initiating repair and shall obtain approval of repair procedure from the Engineer prior to making repair. Methods which are acceptable to the Engineer and their application are as follows:
 - 1) Abrading and rewelding: For repair of small (less than 12 inches long) sections of seams.
 - 2) Spot welding or seaming: For repair of small tears (less than 2 inches long), pinholes or other minor, localized flaws where geomembrane thickness has been reduced by more than four (4) mils by excessive abrading or other means.
 - 3) Capping: For repair of large lengths of failed seams.
 - 4) Patching: For repair of large (over 3/8-inch diameter) holes, tears (over 2 inches long), undispersed raw material, and contamination by foreign matter.
 - 5) Removing the unsatisfactory material and replacing with new material seamed into place.

- b. In addition, the following procedures shall be satisfied:
 - 1) Surfaces of the geomembrane which are to be repaired shall be abraded no more than one-half (1/2) hour prior to the repair.
 - 2) All surfaces shall be clean and dry at the time of repair.
 - 3) Patches or caps shall extend at least six (6) inches beyond the edge of the defect and all corners of patches shall be rounded with a radius of at least three (3) inches.
 - 4) The geomembrane below large caps shall be cut to avoid water or gas collection between the sheets.
3. Verification of Repairs - Each patch shall be numbered and logged. Each repair shall be non-destructively tested using the methods described in Section 9-35.1(7) of these Special Provisions. Repairs which pass the non-destructive test shall be considered an adequate repair. Large caps shall be of sufficient length to require destructive test sampling, at the discretion of the Engineer. Repairs that have failed tests shall be redone and retested until a passing test results.

9-35.1(6)F. Weather Conditions

Geomembrane deployment will not occur during any precipitation, in the presence of excessive moisture (fog, dew), in an area of standing water, or during high winds.

9-35.1(7) Testing

9-35.1(7)A. General:

1. Manufacturer and installer shall participate in and conform with all terms and requirements of the Owner's quality assurance program and shall perform their own quality control program. The Contractor shall be responsible for assuring participation. Quality assurance requirements are as specified herein.
2. Quality control testing, including observation of the production and installation of the geosynthetics and laboratory testing of representative samples of the geosynthetics obtained during the installation, shall be performed by the Contractor. The Contractor shall provide the services of a Quality Control Technical Representative from the geomembrane manufacturer or installer to ensure compliance with the manufacturer's recommendations for handling and installing the geomembrane. The Quality Control Technical Representative shall be present during installation, instruct the installers, observe the work, report unsatisfactory conditions, supervise testing, and make recommendations to the installer. Laboratory testing, field seam testing, and destructive testing shall be performed by the Contractor and observed by the Engineer.
3. Field seams shall be non-destructively tested over their full length using a vacuum test unit, air pressure (for double fusion seams only) or other approved methods. Non-destructive testing shall be carried out as the seaming progresses, not at the completion of all the field seaming. Required repairs shall be as specified herein.

9-35.1(7)B. Conformance Testing

Upon delivery of the geomembrane rolls, the Engineer may take additional samples beyond the minimum frequency stated below, and forward to a Geosynthetic Laboratory. Geosynthetic QA information shall be supplied by the material manufacturers and any associated subcontractors to ensure conformance to these specifications. The following shall be performed by the Geosynthetic Quality Assurance Laboratory:

1. Tests to determine the following characteristics shall be performed on the geomembranes.
 - a) Density
 - b) Carbon Black Content
 - c) Carbon Black Dispersion
 - d) Thickness (measured with micrometer or by weight per square area using laboratory-determined specific gravity, at several random locations on the sample.)
 - e) Tensile characteristics (yield strength, elongation at yield, break strength, elongation at break.)
 - f) Seam strength.
 - g) Puncture and tear resistance tests.
2. Test procedures shall comply with the following:
 - a) Density (ASTM D 792 Method A or ASTM D 1505)
 - b) Thickness (ASTM D 1593 or ASTM D 5994)
 - c) Tensile Strength (ASTM D 638)
 - d) Carbon Black Content (ASTM D 1603)
 - e) Carbon Black Dispersion (ASTM D 3015)
3. Sampling Procedures:
 - a) Samples shall be taken across the entire width of the roll and shall not include the first three feet. Unless otherwise specified, samples shall be taken at a rate of one per lot/batch or one per one hundred thousand (100,000) square feet, whichever is greater.
4. Test Results - The Geosynthetic Quality Assurance Laboratory shall provide copies of all test results to the Contractor and Engineer. The Engineer shall examine all results from laboratory conformance testing and shall report any non-conformance to the Contractor. Non-conforming areas shall be repaired as specified in 9-35.1(6)E of these Special Provisions.

9-35.1(7)C. Vacuum Testing:

1. Vacuum testing shall meet the following requirements:
 - a. The equipment shall consist of the following:

- 1) A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole, or valve assembly, and a vacuum gauge.
- 2) A steel vacuum tank and pump assembly equipped with a pressure control and pipe connections.
- 3) A rubber pressure/vacuum hose with fittings and connections.
- 4) A soapy solution and applicator.
- b. The following procedures shall be followed:
 - 1) Energize the vacuum pump and reduce the tank pressure to approximately ten (10) inches of water.
 - 2) Place the box over the wetted seam area (soapy solution).
 - 3) Ensure that a leak-tight seal is created.
 - 4) For a period of not less than fifteen (15) seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.
 - 5) All areas where soap bubbles appear shall be marked and repaired in accordance with repair procedures described in Section 9-35.1(6)E of these Specifications.

9-35.1(7)D. Air Pressure Testing

The following procedures are applicable to those processes which produce a double seam with an enclosed space:

1. The equipment shall consist of the following:
 - a. An air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining a pressure over forty (40) psi and mounted on a cushion to protect the geomembrane.
 - b. A rubber hose with fittings and connections.
 - c. A sharp hollow needle, or other approved pressure feed device.
 - d. A pressure gauge with an accuracy of one (1) psi.
2. The following procedures shall be followed:
 - a. Seal both ends of the seam to be tested.
 - b. Insert needle or other approved pressure feed device into the tunnel created by the fusion weld.
 - c. Energize the air pump to a minimum pressure of forty (40) psi, close valve, and sustain pressure for at least five (5) minutes.
 - d. If loss of pressure exceeds two (2) psi or ten (10) mm mercury or does not stabilize, locate faulty area and repair in accordance with repair procedures described in this Specification.
 - e. Puncture opposite end of the seam to release air. If blockage is present, locate and re-test seam on both sides of blockage.
 - f. Remove needle or other approved pressure feed device and repair the penetration holes using methods specified in Section 9-35.1(6)E of these Special Provisions.

9-35.1(7)E. Destructive Testing:

1. General - The Engineer will direct the Contractor to perform destructive seam tests at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing shall be performed as the seaming work progresses, not at the completion of all field seaming.
2. Location and Frequency:
 - a. Destructive test samples shall be collected at a minimum frequency of one (1) test location per five hundred (500) feet of seam length.
 - b. Samples, in addition to the minimum frequency, shall be taken as required by the Engineer.
 - c. Test location shall be determined during seaming and may be prompted by suspicion of excess heating, contamination, offset welds, or any other potential cause of imperfect welding. The Engineer will select the locations. The Engineer will not notify the Installer in advance of selecting locations where seam samples will be taken.
 - d. The Engineer reserves the right to increase the frequency in accordance with the actual performance results of samples taken.
3. Sampling Procedure:
 - a. Samples shall be cut at locations designated by the Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number, date, and ambient temperature. The sample location will be identified on the panel layout drawing.
 - b. All holes in the geomembrane resulting from destructive sampling shall be immediately repaired in accordance with repair procedures specified in Section 9-35.1(6)E of these Special Provisions.
4. Size of Samples - The samples shall be twelve (12) inches wide by forty-six (46) inches long with the seam centered lengthwise. Two (2) 1-inch wide strips shall be cut from each end of the sample and these shall be tested (shear and peel) in the field by the installer. The remaining sample shall be cut into three (3) parts and distributed as follows:
 - a. One (1) portion for the Contractor, twelve (12) inches by twelve (12) inches.
 - b. One (1) portion for testing by the Contractor's laboratory, 12 inches by 18 inches.
 - c. One (1) portion to the Engineer or archive storage, twelve (12) inches by twelve (12) inches.
5. Field Testing - The two (2), one (1) inch wide strips described in Section 9-35.1(7)E.4 above shall be tested in the field by the installer and witnessed by the Engineer, by tensiometer, for peel and shear, respectively. Test strips shall meet the peel and shear values specified for trial seams in Section 9-35.1(6)D.4. If any

field test sample fails to pass, then the procedures outlined in that Section shall be applied.

6. Laboratory Testing - Laboratory testing shall be performed by the Geosynthetic Quality Assurance Laboratory paid for by the Contractor and approved by the Engineer. Testing shall include "Seam Strength" and "Peel Adhesion" (ASTM D638 with Type M-1, specimen one-half (1/2) inches wide, tested at two (2) inches per minute). The minimum acceptable values to be obtained in these tests are those indicated herein. At least five (5) specimens shall be tested for each test method. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear). If laboratory testing yields results less than the minimum values specified herein, the procedures defined in the following Section shall be applied.
7. Procedures for Destructive Test Failure - The following procedures shall apply whenever a sample fails the destructive test, whether performed by field or laboratory testing:
 - a. The seam shall be reconstructed between any two (2) passed test locations, or
 - b. The seaming path can be traced to an intermediate location (at least ten (10) feet minimum from the location of the failed test in each direction) and a small sample taken for an additional field test at each location. If these additional samples pass the field tests, then full laboratory samples shall be taken. If these laboratory samples pass, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed.
8. Acceptance of Seams - All acceptable seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken. In cases exceeding one hundred and fifty (150) feet of reconstructed seam, a sample taken from within the reconstruction zone must pass destructive testing. Whenever a sample fails, additional testing may be required for seams that were seamed by the same personnel and/or apparatus or seamed during the same time shift.

9-35.1(7)F. Geomembrane Wrinkle

When seaming of a geomembrane liner is completed, or when seaming of a large area of a geomembrane liner is completed, and prior to placing overlying materials, the Engineer shall identify the location of excessive geomembrane wrinkles. Wrinkles so identified shall be cut and re-seamed and tested.

9-35.1(7)G. Seams That Cannot Be Non-Destructively Tested

The following procedures shall apply to locations where seams cannot be non-destructively tested:

1. All such seams shall be cap-stripped with the same geomembrane.
2. If the seam is accessible to testing equipment prior to final installation, the seam shall be non-destructively tested prior to final installation.
3. If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations shall be observed by the Engineer and Contractor for uniformity and completeness.

9-35.1(7)H. Geomembrane Acceptance

The Contractor shall retain ownership and responsibility for the geomembrane until acceptance by the Owner. The geomembrane shall be accepted by the Owner when:

1. Conformance test results meet the requirements of the Contract Documents.
2. Required documentation including warranty from the manufacturer, fabricator and installer has been received and accepted.
3. The installation is complete and accepted by the Engineer.
4. Verification of the adequacy of all field seams and repairs, including associated testing, is complete.
5. Written certification documents, including as-built drawings, have been received by the Engineer.

9-35.2 Polyvinyl Chloride (PVC) Geomembrane**9-35.2(1) Acceptable Manufacturers**

Flexible polyvinyl chloride (PVC) film shall be from blends of virgin PVC resins with softening agents (plasticizers) as manufactured by: Layfield Plastics, Inc., 3890 Hammer Drive, Bellingham, WA 98226, Telephone 800-796-6868; HPG International, Inc. 811 West River Drive, Temple Terrace, FL 33617, Telephone 813-983-0868; Integra Plastics, Inc., 500 12th Street S.E., Madison, SD 57042, Telephone 800-578-5257; Watersaver Company, Inc., P.O.Box 16465, Denver, Co 80216-0465, Telephone 303-289-1818; Vernon Plastics Company, P.O. Box 8248, Shelley Road, Haverhill, MA 01835, Telephone 978-373-1551, or an approved equal.

9-35.2(2) Definitions Used in This Section.

1. Air Lance. A commonly used nondestructive test method performed with a stream of air forced through a nozzle at the end of a hollow metal tube to determine seam continuity and tightness of relatively thin, flexible geomembrane.

2. **Bodied Chemical Fusion Agent.** A chemical fluid containing a portion of the parent geomembrane that, after application of pressure and after the passage of time, results in the chemical fusion of two essentially similar geomembrane sheets, leaving behind only that portion of the parent material.
3. **Geomembrane.** An essentially impermeable synthetic membrane used as a solid or liquid barrier. Synonymous with flexible membrane liner (FML).
4. **Seaming Boards.** Smooth wooden boards, conveyor belt, or similar hard surface (preferably 1" X 12" X 8', or more), placed beneath the area to be seamed to provide a uniform surface to apply roller pressure in the fabrication of field seams.
5. **Tensiometer.** A device containing a set of opposing grips used to place a geomembrane seam in tension for evaluating its strength in shear or in peel.
6. **Vacuum Box.** A nondestructive test method which develops a vacuum in a localized region of a geomembrane seam in order to evaluate the seam's tightness and suitability.

9-35.2(3) Quality Assurance

1. **Company qualifications:**
 - a. The installation company shall have worked in a similar capacity on at least 5 projects similar in complexity to this project with each project involving at least 500,000 square feet of similar polyethylene product.
 - b. The installation company shall have installed a minimum of 10 million square feet of polyethylene geomembrane.
2. **Personnel qualifications:**
 - a. Installation supervisor/field engineer shall have worked in a similar capacity on at least 2 jobs similar in size and complexity to this project.
 - b. The master seamer shall have completed a minimum of 5,000,000 square feet of geomembrane seaming work using the type of seaming apparatus *proposed for use on this project*.
 - c. Other seamers shall have seamed a minimum of 1,000,000 square feet of geomembrane.
3. **Manufacturer Source Quality Control.**

The manufacturer shall perform the quality control tests listed in Table 9-35-3 at the manufacturing plant. Quality control certificate shall be provided to the Engineer as specified in Section 9-35.2(4)B of these Special Provisions.

4. Quality Assurance by Owner.

The Owner may engage the services of a Construction Quality Assurance Consultant (CQAC) for monitoring the quality and installation of material. The Contractor shall cooperate fully with supplemental testing performed by the CQAC and shall make available samples required for such testing.

5. Delivery, Storage and Handling

- a. Deliver geomembrane to the site only after the Engineer receives and approves the required submittals. Damaged or unacceptable material shall be immediately removed from the site and replaced at no cost to the Owner.
- b. Space to store the geomembrane rolls or pallets will be designated by the Engineer. Store geomembrane rolls or pallets to protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage. Stack geomembrane no more than 3 rolls or 1 pallet high.
- c. Use appropriate handling equipment to load, move or deploy geomembrane rolls or panels. Appropriate handling equipment includes cloth chokers and spreader bar for loading, spreader and roll bars for deployment. Do not fold geomembrane material. Geomembrane damaged during handling shall be repaired to the satisfaction of the Engineer. Geomembrane irreparably damaged, as determined by the Engineer, shall be immediately removed from the site and replaced. Repair, removal and replacement shall be solely at the Contractor's expense.
- d. Upon mobilization to the site the Engineer shall perform the following:
 - 1) Verify the equipment used on site is adequate and does not risk damage to the geomembrane or other materials.
 - 2) Mark rolls or portions of rolls which appear damaged.
 - 3) Ensure that rolls are properly labeled and that labeling corresponds with Quality Control documentation and Shipping Bills of Lading.

6. Warranty

- a. The installer of the geomembrane to be used in the work shall warrant his workmanship to be free of defects under normal usage for the proposed application after final acceptance of the work. This warranty shall include, but not be limited to, all seams, anchor trenches, geomembrane attachments to appurtenances, and penetration seals. The geosynthetic installer shall also obtain and furnish the Owner a warranty from the geomembrane manufacturer for the materials used. The material warranty shall be for defects or failure due to weathering, with temperatures ranging from (-) minus 30 degrees Fahrenheit to (+) plus 110 degrees Fahrenheit, during the length of the project.
- b. Should a defect or failure occur within the aforesaid periods, the geosynthetic installer shall bear all costs for repair and/or replacement of the geomembrane and shall in addition bear all costs for the excavation of

any cover backfill that is required to be removed in order to repair and/or replace the geomembrane. All materials removed to allow repairs to be made shall be reinstalled by the geosynthetic installer in accordance with these special provisions.

9-35.2(4) Submittals

- A. Two copies of the following documents shall be submitted by the Contractor no later than 3 weeks prior to production of the geomembrane.
1. Complete written instructions for storage, handling, installation and seaming of the geomembrane which are in compliance with these specifications and conditions of warranty.
 2. Panel layout drawings showing both fabricated and field seams, and details not conforming with the Plans (if any).
 3. Qualifications of the geomembrane fabricator shall include:
 - a. Fabrication schedule
 - b. Resume of the master seamer to be assigned to this project, including dates and duration of employment.
 - c. Resume of the Engineer or fabrication supervisor to be assigned to this project, including dates and duration of employment.
 - d. A list of personnel performing factory seaming operations, along with pertinent experience information.
 4. Qualification of the geomembrane installer, including:
 - a. A drawing showing the installation panel layout identifying both fabricated (if applicable) and field seams, as well as any variance or additional details which deviate from the engineering drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc.
 - b. Installation schedule.
 - c. Resume of the master seamer to be assigned to this project, including dates and duration of employment.
 - d. Resume of the field engineer installation supervisor to be assigned to this project, including dates and duration of employment.
 5. Installer's Quality Control Manual.
- B. The following documents shall be submitted to the Engineer prior to the shipment of the geomembrane to the Site:
1. Polymer compound data
 - a. Statement of production date or dates.
 - b. Laboratory certification that the materials meet Specifications.
 - c. Certification that all materials are from the same manufacturer.
 - d. Copy of quality control certificates issued by manufacturer.

- e. Statement that no reclaimed polymer is added to the compound.
 - 2. Geomembrane data.
 - a. Statement of production date or dates
 - b. Laboratory certification that the materials meet the Specification.
 - c. Copy of quality control certificates issued by the manufacturer.
 - d. Reports of tests defined in Table 9-35-4 from the manufacturer.
 - 3. Manufacturer Source Quality Control test results as specified herein after.
- C. Submit the following prior to start of the geomembrane deployment:
- 1. Equipment list defining field seaming equipment by quantity and type.
 - 2. List of personnel assigned to perform the seaming operations.
 - 3. Sample warranties for material and installation as specified hereinafter for review by the Owner.
 - 4. Certificate of acceptance of prepared subgrade by geomembrane installer for each area to be covered by geomembrane, signed by the installation supervisor.
 - 5. Anchor trenches excavated in clay soils susceptible to desiccation cracks should be excavated only the distance required for that day's liner placement to minimize the potential of desiccation cracking.
- D. During installation, the Contractor shall submit the following QL documentation prepared by the Contractor during installation as specified hereinafter.
- E. Upon completion of the installation, the Contractor shall submit the following:
- 1. Certificate stating the geomembrane has been installed in accordance with the Contract Documents.
 - 2. Manufacturer's and Installer's warranties as specified hereinafter.
 - 3. Record drawings showing location of panels, seams, repairs, patches, and destructive samples, including detailed measurements.

TABLE 9-35-4 PVC LINER SPECIFICATIONS

Property	Test Method*	Units	Environmental PVC Geomembrane	
Thickness (nominal \pm 5%)	ASTM D1593	Mils	20	30
Specific Gravity	ASTM D792		1.2 to 1.3	1.2 to 1.3
Minimum Tensile Properties (each direction):	ASTM D882			
1. Breaking Factor	Method A or B	lbs/inch width	46	69
2. Elongation at Break ¹	Method A or B	%	300	350
3. Modulus at 100% Elongation	Method A or B	lbs/inch width	20	30
Tear Resistance	ASTM D1004	Lbs.	6	8
Low Temperature	ASTM D1790	°F	-15	-20
Dimensional Stability	ASTM D1204	% max. change	3.5	3.5
Water Extraction	ASTM D1239	% loss max.	0.35	0.35
Volatile Loss	ASTM D1203	% loss max.	0.9	0.7
Resist. to soil burial:	ASTM D3083	% Change max.		
1. Breaking Factor			5	5
2. Elongation at Break			20	20
3. Modulus at 100% Elongation			20	20
Hydrostatic Resistance	ASTM D751 Method A	psi	60	85
Factory Seam Requirements ²				
Bonded Seam Strength	ASTM D3083	ppi	35	50
Peel Adhesion	ASTM D413	psi	10	10
¹ The jaw separation method is to be used to determine elongation percent.				
² Factory bonded seam strength is the responsibility of the fabricator.				

9-35.2(5) Materials**9-35.2(5)A Description of Materials**

Geomembrane liner shall be first quality product and manufactured specifically for the purposes of this work and shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes. The liner, resin, and extrudate shall be manufactured by one of the acceptable manufactures listed in Section 9-35.2(1).

9-35.2(5)B Physical Characteristics

1. 100% virgin polyvinyl chloride resin shall be used to formulate the geomembrane. The use of water soluble formulation ingredients is prohibited.
2. Geomembrane shall be uniform in color, thickness, size and surface texture. The material shall be a flexible, durable, watertight product free of pinholes, blisters, holes and contaminants.
3. Geomembrane shall have the minimum physical property characteristics, as outlined in Table 9-35-3. Certified test results showing that the sheeting meets or exceeds this specification shall be submitted per Section 9-35.2(4).

9-35.2(6) Installation**9-35.2(6)A. Subgrade Preparation**

1. The area to be lined shall be drained and allowed to dry until firm enough for equipment to operate without rutting.
2. The surface to be lined shall be smooth and free of projections and sharp objects that can damage the lining. Remove all stumps and roots. Remove rocks, hard clods, and other such material, and roll the subgrade so as to provide a smooth compact surface. The smoothed subgrade will limit liner bridging to less than 1 inch.

9-35.2(6)B. Geomembrane Installation

1. Only install enough panels that can be seamed during that same day.
2. Do not damage geomembrane by handling, traffic, or leakage of hydrocarbons or any other means. Do not wear damaging shoes or engage in activities that could damage the geomembrane. Open or unroll geomembrane panels using methods that will not damage, stretch or crimp the geomembrane. Prevent excess condensation on the geomembrane such that the underlying surface is not adversely impacted. Protect underlying surface from damage. Provide

sufficient material to allow for geomembrane shrinkage and contraction. Use methods that minimize wrinkles between adjacent panels. Place ballast on geomembrane to prevent uplift from wind. Use ballast that will not damage geomembrane. Repair damage to subgrade or other underlying materials prior to completing deployment of geomembrane. Do not allow vehicle traffic directly on geomembrane. Remove folded material. Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for testing and/or repair. Any portion of the lining damaged during installation shall be removed or repaired by using an additional piece of the same membrane as specified herein. The liner shall be installed in a relaxed condition and shall be free of stress or tension upon completion of the installation. Stretching the liner to fit is not permissible.

3. Place and seam geomembrane only when ambient temperatures, measured six inches above the geomembrane, are between 40 degrees F and 100 degrees F, unless otherwise specified or approved. Installation below 40 degrees F shall occur only after verifying that the geomembrane can be seamed according to Specifications and approval by the Engineer. Do not install geomembrane during precipitation, in the presence of excessive moisture, in areas of ponded water, or in the presence of excessive winds.
4. Protect the geomembrane from wind uplift during installation through the use of sand bags or other suitable weights. Repair all damaged geomembrane and test damaged areas prior to backfilling.

9-35.2(6)C. Pipe Boots.

Pipes, manholes, and other penetrations of the geomembrane shall be fitting and sealed with shop fabricated boots as shown on the Plans. The flange portion of the boot shall match the angle of the slope or bottom where the pipe or manhole enters the liner for a smooth fit without excess stretching of the material.

9-35.2(6)D. Seaming

1. Seam Layout - Seam layout shall meet the following requirements:
 - a. Orient seams parallel to line of maximum slope, i.e., orient down, not across, slope.
2. Trial field seaming shall be accomplished by the Contractor on-site and shall meet the following requirements:
 - a. Conduct trial seams on pieces of geomembrane to verify adequate seaming methods and conditions.
 - b. Conduct trial seams:
 - 1) at beginning of each seaming period
 - 2) at least once for each four seaming hours
 - 3) for each seaming apparatus used

- 4) at least once per shift for each person performing seaming
- 5) when changes in climatic conditions or other changes could affect seam quality

Make test seam in the location of seaming and in contact with subgrade or geotextile (same condition as the geomembrane to be seamed.)

- c. Make test seam sample at least two (2) feet long and eleven (11) inches wide with the seam centered lengthwise.
 - d. Cut two, 1-inch wide test strips from opposite ends of the trial seams.
 - e. Cut specimens constant 1-inch wide and clamp at 90 degree angle in tensiometer.
 - f. Quantitatively test field specimens for peel adhesion (ASTM D-3083) first, and bonded seam strength (ASTM D-3083) second. Insure that these tests are performed in this order.
 - g. A trial seam sample passes when the following results are achieved for both tests.
 - 1) the break is film tearing bond (FTB)
 - 2) the break is ductile
 - 3) the strength of break is at least 80% of the specified sheet strength
 - h. Repeat the trial seam in its entirety if one (1) of the trial seam samples fails in either peel or shear mode.
 - i. When repeated trial seam fails, notify Engineer and do not continue seaming until deficiencies or adverse conditions are determined and corrected, and two (2) consecutive successful trial seams are achieved.
3. The seaming procedure used shall be as follows:
- a. Do not begin seaming on liner until all trial seam test samples made by the equipment to be used passes tests as defined above.
 - b. Field seams will be made to seal factory fabricated panels or rolls of geomembrane together in the field. Form seams per manufacturers written instructions. The contact surfaces of the panels shall be wiped clean to remove all dirt, dust or other substance. Solvent for cleaning contact surfaces of field joints and for other required uses shall be as recommended by the manufacturer. A hot wedge or hot knife seaming tool shall be applied to the overlapped panel edges creating a continuous thermal bond between the panels. Any wrinkles shall be smoothed out. Field seams shall have a strength of at least 80% of the specified sheet strength.
 - c. Seaming shall extend to the outside edge of panels
 - d. A firm substrate shall be provided by using a seaming board directly under the seam overlap to achieve proper support.
 - e. If seaming operations are carried out at night, adequate illumination shall be provided.
 - f. "Fish mouths" or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fish mouths or wrinkles shall be seamed and any portion where the overlap is less than three (3) inches shall then be patched with an oval or round

- patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions.
- g. Seam only when ambient temperature, measured 6 inches above the geomembrane is between 40 degrees F and 100 degrees F unless other limits are accepted, in writing, by the Engineer.

9-35.2(6)E. Defects and Repairs

1. Inspection

- a. During installation and seaming, all seams and non-seam areas of the geomembrane shall be visually examined for defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of the examination. Areas suspected of deficiencies shall be marked. Areas of geomembrane requiring more than one patch per 5,000 square feet shall be removed and replaced at no additional cost to the Owner.
- b. Each suspect location both in seam and non-seam areas shall be repaired and non-destructively tested. Work shall not proceed with any materials which will cover locations which have been repaired until passing test results are achieved.

2. Repair Procedures

- a. Repair all portions of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. The Contractor shall provide a written recommendation for method of repair to the Engineer prior to initiating repair and shall obtain approval of the repair procedure from the Engineer prior to making repair. Methods which are acceptable to the Engineer and their application are as follows:
- 1) Capping. Cap for repair of large lengths of failed seams.
 - 2) Patching. Patch large (over 3/8 inch diameter) holes, tears (over 2 inches long), undispersed raw material, and contamination by foreign matter.
 - 3) Remove and Replace. Remove the unsatisfactory material and replace with new material seamed into place.
- b. In addition, the following procedures shall be satisfied:
- 1) Abrade surfaces of the geomembrane which need repaired no more than one-half (1/2) hour prior to the repair.
 - 2) Clean and dry all surfaces at the time of repair.
 - 3) Extend patches or caps at least six (6) inches beyond the edge of the defect and all corners of patches shall be rounded with a radius of at least three (3) inches.
 - 4) Cut the geomembrane below large caps to avoid water or gas collection between the sheets.

3. Verification of Repairs - Each repair shall be non-destructively tested using the methods described in Section 9-35.2(7) of these Special Provisions. Repairs which pass the non-destructive test shall be considered an adequate repair. Large caps shall be of sufficient length to require destructive test sampling, at the discretion of the Engineer. Repairs that have failed tests shall be redone and retested until a passing test results.

9-35.2(7) Testing

9-35.2(7)A. General

1. Quality control testing, including laboratory testing, field seam testing, and destructive testing shall be performed by the Contractor and observed at the discretion by the Engineer.
2. Field seams shall be non-destructively tested over their full length by pressurizing the seam if a dual-hot-wedge method was used in seaming, or using a vacuum test unit or other approved methods. Non-destructive testing shall be carried out as the seaming progresses, not at the completion of all the field seaming. Required repairs shall be as specified herein.

9-35.2(7)B. Vacuum testing shall meet the following requirements.

1. The equipment shall consist of the following:
 - a. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole, or valve assembly, and a vacuum gauge.
 - b. A steel vacuum tank and pump assembly equipped with a pressure control and pipe connections.
 - c. A rubber pressure/vacuum hose with fittings and connections.
 - d. A soapy solution and applicator.
 - 1) The following procedures shall be followed:
 - (a) Energize the vacuum pump and reduce the tank pressure to approximately ten (10) inches of water.
 - (b) Place the box over the wetted seam area (soapy solution).
 - (c) Ensure that a leak-tight seal is created.
 - (d) For a period of not less than fifteen (15) seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.
 - (e) All areas where soap bubbles appear shall be marked and repaired in accordance with repair procedures described in Special Provision Section 9-35.2(6)E.
 - (f) Conduct vacuum testing per ASTM 4437.

9-35.2(7)C. Air Lance Testing shall meet the following requirements:

1. Equipment shall consist of a 3/32" air nozzle that can provide a minimum air pressure of 30 psi and a maximum air pressure of 40 psi.
2. The following procedures shall be followed:
 - a. The air nozzle shall be held at a 45 degree angle to the field seam approximately 2" off the edge of the material.
 - b. The air shall be directed toward the seam edge, upper edge and surface to detect loose edges.
 - c. Riffles indicating unbonded areas within the seam or other undesirable seam conditions shall be patched in accordance with repair procedures described in Special Provision Section 9-35.2(6)E. The patch should then be tested using the same air lance test method.
 - d. Conduct air lance testing per ASTM 4437.

9-35.2(7)D. Destructive Testing

1. The Engineer will direct the Contractor to perform destructive seam tests at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing shall be performed as the seaming work progresses, not at the completion of all field seaming.
2. Location and Frequency
 - a. Destructive test samples shall be collected at a minimum frequency of one (1) test location per five hundred (500) feet of seam length.
 - b. Samples, in addition to the minimum frequency, shall be taken as required by the Engineer.
 - c. Test location shall be determined during seaming and may be prompted by suspicion of insufficient adhesive, contamination, offsets, or any other potential cause of imperfect seaming. The Engineer will select the locations. The Engineer will not notify the Installer in advance of selecting locations where seam samples will be taken.
 - d. The Engineer reserves the right to increase the frequency in accordance with the actual performance results of samples taken.
3. Sampling Procedure
 - a. Samples shall be cut at locations designated by the Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel layout drawing.
 - b. All holes in the geomembrane resulting from destructive sampling shall be immediately repaired in accordance with repair procedures specified in Special Provision Section 9-35.2(6)E.
4. Size of Samples - The samples shall be eleven (11) inches wide by twenty-four (24) inches long with the seam centered lengthwise. Two (2) 1-inch wide strips

- shall be cut from each end of the sample and these shall be tested (shear and peel) in the field by the installer. The remaining sample shall be cut into two (2) parts and distributed as follows:
- a. One (1) portion for the Contractor, eleven (11) inches by eleven (11) inches.
 - b. One (1) portion to the Engineer or archive storage, eleven (11) inches by eleven (11) inches.
5. Field Testing - The two (2), one (1) inch wide strips described in Special Provision Section 9-35.2(7)D.4 shall be tested in the field by the installer and witnessed by the Engineer, by tensiometer, for peel and shear, respectively. Test strips shall meet the peel and shear values specified for trial seams in Special Provision Section 9-35.2(6)D. If any field test sample fails to pass, then the procedures outlined in that Section shall be applied.
6. Procedures for Destructive Test Failure - The following procedures shall apply whenever a sample fails the destructive test, whether performed by field or laboratory testing:
- a. The seam shall be reconstructed between any two (2) passed test locations, or
 - b. The seaming path can be traced to an intermediate location (at least ten (10) feet minimum from the location of the failed test in each direction) and a small sample taken for an additional field test at each location. If these additional samples pass the field tests, then full laboratory samples shall be taken. If these laboratory samples pass, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed.
7. Acceptance of Seams - All acceptable seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken. In cases exceeding one hundred and fifty (150) feet of reconstructed seam, a sample taken from within the reconstruction zone must pass destructive testing. Whenever a sample fails, additional testing may be required for seams that were seamed by the same personnel and/or apparatus or seamed during the same time shift.

9-35.2(7)E. Geomembrane Wrinkle.

When seaming of a geomembrane liner is completed, or when seaming of a large area of a geomembrane liner is completed, and prior to placing overlying materials, the Engineer shall identify the location of excessive geomembrane wrinkles. Wrinkles so identified shall be cut, re-seamed and tested.

9-35.2(7)F. Seams That Cannot Be Non-Destructively Tested

The following procedures shall apply to locations where seams cannot be non-destructively tested:

1. All such seams shall be cap-stripped with the same geomembrane.
2. If the seam is accessible to testing equipment prior to final installation, the seam shall be non-destructively tested prior to final installation.

9-35.2(7)G. Engineering Observation.

If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations shall be observed by the Engineer and Contractor for uniformity and completeness.

9-35.2(7)H. Geomembrane Acceptance.

The Contractor shall retain ownership and responsibility for the geomembrane until acceptance by the Owner. The geomembrane shall be accepted by the Owner when:

1. Conformance test results meet the requirements of the Contract Documents.
2. Required documentation including warranty from the manufacturer, fabricator and installer has been received and accepted.
3. The installation is complete and accepted by the Engineer.
4. Verification of the adequacy of all field seams and repairs, including associated testing, is complete.
5. Written certification documents, including as-built drawings, have been received by the Engineer.

9-35.3 Geosynthetic Clay Liner (GCL)

9-35.3(1) Acceptable Manufacturers

Geosynthetic clay liner material shall be a sodium bentonite-geotextile composite material; "Bentomat " or "Claymax" as manufactured by Colloid Environmental Technologies Co., 1350 West Shure Drive, Arlington Heights, IL 60004, Telephone 847-577-5589; "Bentofix" as manufactured by National Seal Co., 1245 Corporate Boulevard, Suite 300, Aurora, IL 60504, Telephone 1-800-323-3820, or an approved equal.

Accessory bentonite to be used for placement along seams and around penetrations shall be pure, granular sodium bentonite.

9-35.3(2) Definitions Used In This Section

Geosynthetic Clay Liner (GCL). A manufactured hydraulic barrier consisting of clay bonded to a layer or layers of geosynthetics. The GCL may be reinforced or unreinforced as required by site conditions.

Geomembrane. An essentially impermeable geosynthetic composed of one or more geosynthetic sheets.

Geotextile. Any permeable textile used with foundation, soil, rock, earth, or any other geotechnical engineering related material as an integral part of a human-made project, structure or system.

Minimum Average Roll Value. The minimum average value of a particular physical property of a material, for 95 percent of all of the material in the lot.

Overlap. Where two adjacent GCL panels contact, the distance measuring perpendicular from the overlying edge of one panel to the underlying edge of the other.

9-35.3(3) Quality Assurance

1. **Manufacturer's Qualifications:**
The GCL manufacturer must have produced at least 10 million ft² of GCL, with at least 8 million square feet installed.
2. **Installer's Qualifications:**
The GCL installer must either have installed at least 1 million ft² of GCL, or must provide to the Engineer satisfactory evidence, # through # similar experience in the installation of other types of geosynthetics, that the GCL will be installed in a competent, professional manner.
3. **Product Quality Documentation:**
The GCL manufacturer shall provide the Engineer with manufacturing QA/QC certification for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer and shall include:
 - a. Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the parameters swell index and fluid loss.
 - b. Manufacturer's test data for finished GCL product(s) of bentonite mass/area, GCL tensile strength and GCL peel strength (if applicable) demonstrating compliance with the index parameters.
 - c. GCL lot and roll numbers supplied for the project (with corresponding shipping information).
 - d. Manufacturer's test data for finished GCL product(s) of GCL index flux, permeability and hydrated internal shear strength data demonstrating compliance with the performance parameters.

4. Quality Assurance by Owner.

The Owner may engage the services of a Construction Quality Assurance Consultant (CQAC) for monitoring the quality and installation of material. The Contractor shall cooperate fully with supplemental testing performed by the CQAC and shall make available samples required for such testing.

5. Delivery, Storage and Handling

- a. Deliver GCL to the site only after the Engineer receives and approves the required submittals. Damaged or unacceptable material shall be immediately removed from the site and replaced at no cost to the owner.
- b. Prior to shipment, the GCL manufacturer shall label each roll, identifying:
 - 1) Product identification information (Manufacturer's name and address, brand name, product code).
 - 2) Lot number and roll number.
 - 3) Roll length and weight.
- c. The GCL shall be wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit.
- d. All rolls shall be labeled and bagged in packaging that is resistant to photodegradation by ultraviolet (UV) rays.
- e. The manufacturer assumes responsibility for initial loading the GCL. Shipping will be the responsibility of the party paying the freight. Unloading, on-site handling and storage of the GCL are the responsibility of the Contractor, Installer or other designated party.
- f. A visual inspection of each roll should be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection. The packaging should be repaired prior to being placed in storage.
- g. The party responsible for unloading the GCL should contact the manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.
- h. Storage of the GCL rolls shall be the responsibility of the installer. A dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry and well-drained.
- i. Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks or by use of the dunnage shipped between rolls. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four).
- j. All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.
- k. The integrity and legibility of the labels shall be preserved during storage.

6. Warranty

- a. The installer of the GCL to be used in the work shall warrant his workmanship to be free of defects for two (2) years after final acceptance of the work. This warranty shall include, but not be limited to, all seams, anchor trenches, GCL attachments to appurtenances, and penetration seals. The GCL installer shall also obtain and furnish the Owner a warranty from the GCL manufacturer for the materials used. The material warranty shall be for defects or failure due to weathering for 10 years, with temperatures ranging from (-) minus 30 degrees Fahrenheit to (+) plus 110 degrees Fahrenheit, after the completion of the work on a prorata basis.
- b. Should a defect or failure occur within the aforesaid periods, the GCL installer shall bear all costs for repair and/or replacement of the GCL and shall in addition bear all costs for the excavation of any cover backfill that is required to be removed in order to repair and/or replace the GCL. All materials removed to allow repairs to be made shall be reinstalled by the GCL installer in accordance with these special provisions.

9-35.3(4) Submittals

Two copies of the following documents shall be submitted by the Contractor at least 3 weeks prior to the shipment of the GCL to the site.

1. Conceptual description of the proposed plan for placement of the GCL panels over the area of installation.
2. GCL manufacturer's MQC Plan for documenting compliance of these specifications.
3. A representative sample of the GCLs.
4. A project reference list for the GCL(s) consisting of the principal details for at least ten projects totaling at least 10 million square feet in size.
5. Upon shipment, the Contractor shall furnish the GCL manufacturer's Quality Assurance/Quality Control (QA/QC) certifications to verify that the materials supplied for the project are in accordance with the requirements of this specification.

9-35.3(5) Materials

1. The GCLs shall consist of a layer of natural sodium bentonite clay encapsulated between two nonwoven geotextiles and shall comply with all of the criteria listed in this specification.
2. Reinforced GCL shall be used on this project.
3. Acceptable GCL products are Bentomat™ ST, Bentomat™ DN, and Claymax™ 600SP, as manufactured by Colloid Environmental Technologies Co.; Bentofix as manufactured by National Seal Company.

4. The minimum acceptable dimensions of full-size GCL panels shall be 150 feet in length and 13.8 feet in width. Short rolls (those manufactured to a length greater than 70 feet but less than a full-length roll) may be supplied at a rate no greater than 3 per truckload or 3 rolls every 36,000 square of GCL, whichever is less.
5. A 12 -inch overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing quality assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.
6. The granular bentonite or bentonite sealing compound used for seaming, penetration sealing and repairs shall be made from the same natural sodium bentonite as used in the GCL and shall be as recommended by the GCL manufacturer.

9-35.3(6) Installation

9-35.3(6)A. Subgrade Preparation

1. Any earthen surface upon which the GCL is installed shall be prepared and compacted in accordance with the project specifications and Plans. The surface shall be smooth, firm, and unyielding, and free of:
 - a. Vegetations.
 - b. Construction Debris.
 - c. Sticks.
 - d. Sharp rocks.
 - e. Void spaces.
 - f. Ice .
 - g. Abrupt elevations changes.
 - h. Standing water.
 - i. Cracks larger than one-quarter inch in width.
 - j. Any other foreign matter that could contact the GCL.
2. Subgrade surfaces consisting of granular soils or gravel may not be acceptable due to their large void fraction and puncture potential. Subgrade soils should possess a particle size distribution such that at least 80 percent of the soil is finer than a #60 sieve.
3. Immediately prior to GCL deployment, the subgrade shall be final-graded to fill in all voids or cracks and then smooth-rolled to provide the best practicable surface for the GCL. At completion of this activity, no wheel ruts, footprints or other irregularities shall exist in the subgrade. Furthermore, all protrusions, extending more than one-half inch from the surface shall either be removed, crushed or pushed into the surface with a smooth-drum compactor.
4. On a continuing basis, the project CQA inspector shall certify acceptance of the subgrade before GCL placement.
5. It shall be the installer's responsibility thereafter to indicate to the Engineer any change in the condition of the subgrade that could cause the subgrade to be out of compliance with any of the requirements listed in this Section.

6. At the top of sloped areas of the job site, an anchor trench for the GCL shall be excavated in accordance with the project plans. The trench shall be excavated and approved by the CQA Inspector prior to the GCL placement. No loose soil shall be allowed at the bottom of the trench and no sharp corners or protrusions shall exist anywhere within the trench.

9-35.3(6)B. GCL Placement

1. Reinforced GCL shall be placed on the sloped walls of the OCF cell.
2. GCL rolls should be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging should be carefully removed without damaging the GCL. The orientation of the GCL (i.e., which side faces up) should be in accordance with the Engineer's or manufacturer's recommendations. Unless otherwise specified, however, the GCL shall be installed such that the product name printed on one side of the GCL faces up.
3. Equipment which could damage the GCL shall not be allowed to travel directly on it. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues.
4. Care must be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. A temporary geosynthetic subgrade covering commonly known as a skip sheet or rub sheet may be used to reduce friction damage during placement.
5. The GCL shall be placed so that seams are parallel to the direction of the slope. Seams should be located at least 3 feet from the toe and crest of slopes steeper than 4H:1V.
6. All GCL panels should lie flat on the underlying surface, with no wrinkles or fold, especially at the exposed edges of the panels.
7. Only as much GCL shall be deployed as can be covered at the end of the working day with soil, a geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it will be removed and replaced. The Engineers, CQA inspector, and GCL supplier should be consulted for specific guidance if premature hydration occurs.

9-35.3(6)C. Anchorage

As directed by the Plans, the end of the GCL roll shall be placed in an anchor trench at the top of the slope. The front edge of the trench should be rounded so as to eliminate any sharp corners. Loose soil should be removed from the floor of the trench. The GCL should cover the entire trench floor and the rear trench wall.

9-35.3(6)D. Seaming

1. The GCL seams are constructed by overlapping their adjacent edges. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. Supplemental bentonite is required if the GCL has one or more non-woven needlepunched geotextiles.
2. The minimum dimension of the longitudinal overlap should be 12 inches. End-of-roll overlapped seams should be similarly constructed, but the minimum overlap should measure 24 inches.
3. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.
4. Bentonite-enhanced seams are constructed between the overlapping adjacent panels and described above. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the 12-inch line. A similar bead of granular sodium bentonite is applied at the end-of-roll overlap. The bentonite shall be applied at a minimum application rate of one quarter pound per lineal foot.

9-35.3(6)E. Detail Work

1. The GCL shall be sealed around penetrations and embedded structures embedded in accordance with the design drawings and the GCL manufacturer.
2. Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid damage to the geotextile components of the GCL during the cutting process.

9-35.3(6)F. Damage Repair

If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 12 inches is achieved around all of the damaged area. Dry bentonite or bentonite mastic should be applied around the damaged area prior to placement of the patch. It may be desirable to use an adhesive to affix the patch in place so that it is not displaced during cover placement.

9-35.3(6)G. Cover Placement

1. Cover soils shall be free of angular stones or other foreign matter which could damage the GCL. Cover soils should be approved by the Engineer with respect to particle size, uniformity, and chemical compatibility. Cover soils with high concentrations of calcium (e.g., limestone, dolomite) are not acceptable.
2. Soil cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. A minimum thickness of 1 foot of cover should be maintained between the equipment tires/tracks and the GCL at all times during

the covering process. This thickness recommendation does not apply to frequently trafficked areas or roadways, for which a minimum thickness of 2 feet is required.

3. Soil cover should be placed in a manner that prevents the soil from entering the GCL overlap zones. Cover soil shall be pushed up slopes, not down slopes to minimize tensile forces on the GCL.
4. Although direct vehicular contact with the GCL is to be avoided, lightweight, low ground pressure vehicles (such as 4-wheel all-terrain vehicles) may be used to facilitate the installation of any geosynthetic material placed over the GCL. The GCL supplier or CQA engineer should be contacted with specific recommendations on the appropriate procedures in this situation.
5. When a textured geomembrane is installed over the GCL, a temporary geosynthetic covering known as a slip sheet or rub sheet should be used to minimize friction during placement and to allow the textured geomembrane to be more easily moved into its final position.

9-36 LEACHATE COLLECTION PUMPING SYSTEM - Add the following new section:

All materials and equipment incorporated in the system shall be new, undamaged, of standard quality, and shall be subject to testing as specified.

9-36.1 Pump

Leachate collection pump shall be a Slanted Well Canister Pump, as manufactured by Clean Environment Equipment, 1133 Seventh Street, Oakland, CA 94607, Telephone 1-800-537-1767; or an approved equal.

The pump shall consist of an Autopump (an automatic, controllerless, air-displacement pump), filter/pressure regulator, control panel, hose, quick connects, and hardware package. The control system shall include tank-full shut off safety system.

The temporary leachate collection pump shall be a submersible pump capable of pumping 50 gpm at a TDH of 80 feet, with liquid level controls.

9-36.2 Compressor

The compressor shall consist of a Speedaire Cast Iron Series, Stock No. 72167, engine driven compressor (4 HP, single phase, 230 Volt, delivering 8.5 cfm at 100 psi, 30 gal. air tank) distributed and sold by W.W. Grainger, Inc., or an approved equal.

9-36.3 Vault

The air compressor equipment vault (Vault #1) shall be a 680-FC Containment Vault (8'L x 6'W x 7'H inside dimensions) as manufactured by Utility Vault Co., P.O.Box 610, Chandler, AR 85244, Telephone 602-963-2676, or an approved equal.

The leachate storage tank vault (Vault #2) shall be a 810-FC Containment Vault (10'L x 8'W x 7'H inside dimensions) as manufactured by Utility Vault Co, or an approved equal.

Vaults shall have cut outs for manway access riser, ventilation stack, and necessary conduits. Manway access riser shall be closed with a waterproof, locking access cover.

Vaults #1 and # 2 shall have the bottom interior section of the vault waterproofed with a slurry coat, as manufactured by XYPEX Chemical Corporation, 13731 Mayfield Place, Richmond, B.C., Canada V6V 2G9, Telephone 604-273-5265, or an approved equal. The waterproofing materials shall be applied in accordance with the manufacturer's specifications.

9-36.4 Leachate Storage Tank

The leachate storage tank shall be a fiberglass tank (5' diameter x 7'L) with a capacity of 1000 gallons. The tank will be fitted with floats to activate the alarm system when the tank contains 750 gallons and to deactivate the pump from the cell when the tank contains 950 gallons.

9-36.4(1) Submittals

The Contractor shall submit a written assessment, reviewed and certified by an independent qualified registered professional engineer that the tank system has sufficient structural integrity and is acceptable for the storing and treating of hazardous waste as specified in 40 CFR Section 264.192(a).

The Contractor shall submit an inspection report from an independent, qualified installation inspector or independent qualified, registered professional engineer that the tank system is in accordance with 40 CFR Section 264.192(b).

9-36.5 Miscellaneous Leachate Collection Equipment

9-36.5(1) Ventilation

Ventilator in Vault #1 shall be a 1/2 HP Fume Master Exhaust Fan as manufactured by Lab Safety Supply, P.O.Box 1368, Janesville, WI 53547, Telephone 800-543-9910, or an approved equal. The ventilator shall be rated at 345 cfm and provide a minimum of 30 air changes an hour. The ventilator in Vault #2 shall be a 1/2 HP Fume Master Exhaust Fan as manufactured by Lab Safety Supply, or an approved equal. The ventilator shall be rated at 360 cfm and provide at a minimum of 30 air changes per hour.

9-37 PREFABRICATED VERTICAL DRAIN - Add the following new section:

The prefabricated vertical drain shall be a continuous polypropylene drainage core wrapped in a nonwoven filter fabric of continuous polypropylene filaments. The fabric wrap shall be tight around the core, and shall be securely seamed in a manner that will not introduce any materials into or impede flow in the channels of the core.

The prefabricated vertical drain shall meet specific dimensions and physical properties listed in Table 9-37-1.

TABLE 9-37-1 PREFABRICATED VERTICAL DRAIN SPECIFICATIONS

PROPERTY		VALUE	TEST METHOD
Drain	Weight	75-93 g/m	
	Width	93-100 mm	
	Thickness	3 mm	ASTM D5199
	Discharge Capacity	1.1×10^{-4} m ³ /sec	ASTM D4751
	Water Permeability (k)	7.0×10^{-4} m/sec	
	Free Volume	180 mm ³ /mm	
Core	Grab Tensile Strength	0.8 kN	ASTM D638
Fabric:	Grab Tensile Strength	0.53 kN	ASTM D4632
	Elongation at Break	>50%	ASTM D4632
	Modulus at 10% Elongation	2.6 kN	ASTM D4632
	Trapezoidal Tear	0.25 kN	ASTM D4533
	Puncture Strength	0.16 kN	ASTM D4833
	Mullen Burst	950 kPa	ASTM D3786
	Specific Gravity	0.95	
	Flux	1,140 lpm/m ²	ASTM D4491
	Permittivity	1.25 sec ⁻¹	ASTM D4491

Note: Core Grab Tensile Strength shall be 2.0 kN for PVDs installed in DDC area.

The prefabricated vertical drain shall be new material free of defects, rips, holes, and flaws. The materials shall be stored to protect it from sunlight, mud, dirt, debris, and other detrimental substances. The Contractor shall furnish to the Engineer, the manufacturer's certification for all drain materials delivered to the Site.

The prefabricated vertical drain (wick) spacing is shown on the plans.

9-38 POLYPROPYLENE SUPERSACKS - Add the following new section:

The following polypropylene "Supersack" shall consist of a heavy woven fabric having a minimum capacity of 3000 pounds. The bags shall have reinforced corners for maximized lifting capacity. Body seams shall have 4 ply stitching for strength.

9-38.1 Acceptable Manufacturers

Polypropylene "Supersacks" shall be bulk bags as manufactured by Amoco Fabrics Company, Patchogue Plymouth Division, 550 Interstate North, Suite 150, Atlanta, Georgia 30099, Telephone (404) 955-0935, or an approved equal.

The bags shall meet specific dimensions and physical properties listed in Table 9-38-1.

TABLE 9-38-1 POLYPROPYLENE SUPERSACK SPECIFICATIONS

Property	Units	Value	Test Method
Tensile Strength (Warp/Fill)	Lbs.	275x275	ASTM D 4632
Trapezoid Tear Strength	Lbs.	120x120	ASTM D 4533
Burst Strength	PSI	600	ASTM D 3786
Puncture Strength	PSI	100	ASTM D 4833
Weight	oz/sq. yd.	6.5	ASTM D 1910
UV Resistance	% Strength Retained	>70	Federal Test Method 5804 Standard 191 A

9-39 GEOGRIDS

The geogrids shall consist of high strength, high molecular weight polyester geogrid. The geogrid shall be woven polyester fibers coated with polymer to provide dimensional stability.

9-39.1 Acceptable Manufacturer's

Geogrids shall be for soil reinforcement applications as manufactured by Mirafi, 365 South Holland Drive, Pendergrass, Georgia 30567, Telephone (706) 693-2226, or an approved equal.

Geogrids shall meet specific dimensions and physical properties listed in Table 9-39-1.

TABLE 9-39-1 GEOGRID SPECIFICATIONS

Property	Test Methods	24XT
Polymer (Coating)		PET (PVC)
Ultimate Wide With Tensile Strength (Lbs/Ft)	ASTM D 4595	25,380
Creep Reduce Strength (Lbs/Ft)	ASTM D 5262	14,756
long-term Design Strength (in sand, silt, clay) (Lbs/Ft)	GRI-GGK	12,195
	Packaging	
	Roll Width (Ft)	6.7
	Roll Length* (Ft)	150
	Estimated Roll Weight (Lbs)	281

Note: Standard roll lengths are shown; the products may be fabricated to greater lengths to met project needs.

9-40 ELECTRICAL GENERAL

9-40.1.1 Definitions

- A. The words "plans" and "drawings" are used interchangeably in this specification and in all cases shall be interpreted to mean "drawings".
- B. The word "provide" shall be interpreted to mean furnish and install.
- C. "Owner" shall be the contractor until the completion of construction and acceptance of the project at which time ownership shall be turned over to Asarco.
- D. "Contractor" is the party who furnishes and installs all tools, materials and equipment. This includes the Prime Contractor, the Electrical Contractor, Control System Integrator, and all other Contractors and Sub Contractors.
- E. "Control System Integrator" also referred to as the System Integrator or Integrator is the Party that furnishes all control components and designs the detailed control wiring diagrams plus the layout and assembly of the custom control panels.
- F. "Control System" includes all equipment, instruments and wiring for control and monitoring of all operating pumps and equipment. This includes custom control panels, motor control center, packaged control panels, and control equipment furnished with other systems and mechanical equipment. All sensing, transmitting, indicating, control and recording of all functions as specified and shown are also included in the control system.

9-40.1.2 General Description Of Work

- A. The Contractor shall provide all labor, material, tools, equipment and services required to complete the furnishing, installation, wiring, connection, calibration, adjustment, testing and operation of all electrical equipment, devices and components as indicated and implied by the plans and these specifications.
- B. Complete the wiring to, connection to, adjustment and calibration of, and testing of equipment having electric motors and/or built-in or furnished electrical components. Install electrical components that are furnished with mechanical equipment.
- C. Complete the procurement, installation, wiring, connection, calibration, adjustment, testing and operation of all electrical devices, components, accessories and equipment which is not shown or specified but which is nonetheless required to make the systems shown and specified function properly.
- D. The Contractor shall install and make all connections to the equipment furnished by the Owner.

- E. Provide the size, type and rating of motor control devices, equipment and wiring necessary to match the ratings of motors furnished with mechanical equipment.
- F. Provide adequate space for the electrical installation, including but not limited to, determination of access-ways and doorways, shipping sections, wall and floor space, and space occupied by mechanical equipment. Provide electrical equipment that fits in the areas shown on the drawings. All equipment shall be readily accessible for maintenance, shall have electrical clearances in accordance with NEC and shall be installed in locations which will provide adequate cooling.
- G. Check electrical equipment prior to installation so that defective equipment is not installed. Acceptance testing for electrical equipment shall be performed as discussed in Section 9-44.
- H. Provide start-up, follow-up and training of the owner's personnel for electrical systems. Make all corrective measures required during start-up. See specific requirements for training and start-up in other specification sections.
- I. Provide field services of qualified technicians to supervise and check out the installation of the equipment, to supervise and check out interconnecting wiring, to conduct start-up of operation of the equipment, and to correct any problems which occur during start-up.
- J. Provide circuit breakers, conduit, wire and installation for all items which require 120 VAC power.
- K. The motor control centers, transfer switches, RTU's, control panels, and instrumentation shall be supplied through the Control System Integrator.

9-40.1.3 Equipment Coordination

- A. The Contractor is responsible to coordinate the equipment supplied from various manufacturers. This includes but is not limited to:
 - 1. Obtaining specific information on equipment ratings and sizes and verifying the electrical components supplied meet, or match the requirements such as voltage, phase, frequency, starter types, etc.
 - 2. Verifying the equipment supplied will fit within the space allocated.
 - 3. Coordination of equipment and the electrical power and control requirements provided in all sections of the specifications and drawings.
 - 4. Providing power and control equipment, wiring, and raceways to meet the requirements of the mechanical equipment supplied.
 - 5. Providing all necessary control wiring and components for any special requirements from an equipment manufacturer.

B. The Contractor shall verify as a minimum:

1. Correct voltage, phase and frequency
2. Size and space requirements
3. Mounting requirements
4. Correct motor starter type
5. Proper coordination with the controls and control system integrator.

C. Any discrepancies between the electrical and other equipment shall be brought to the immediate attention of the Engineer.

9-40.1.4 Project Description

A. In general the project consists of providing power for leachate pumping and monitoring.

B. The following statements highlight the main portion of the electrical work:

1. Coordinate with the local power utility and provide power service to the site.
2. Power Vault #1 compressor, temporary pump, lighting and ventilation.
3. Power Vault #2 lighting and ventilation and monitor tank.
4. Monitor the tank level and vault flood conditions with an Alarm panel near Vault #2.

9-40.1.5 Temporary Operation And Construction Power

9-40.1.5.1 Facility Operation Power

- A. If necessary, provide temporary power service for facility operation during construction. Provide power and control systems, circuits and components, and connections for all motors and equipment that remains in operation during construction. The Contractor shall pay for all coordination with the utility and associated construction costs for temporary facility power.
- B. Any necessary modifications to the existing electrical system for construction power shall be coordinated and paid for by the Contractor.
- C. The Owner shall pay for the energy costs as billed by the utility and these costs shall not be included in the Contractors bid price.

9.40.1.5.2 Construction Power

- A. If the existing service is adequate for facility operation and construction power, then the existing service may be used for construction power and the Owner shall pay all energy costs as billed by the utility on the existing meter.
- B. Any necessary modifications to the existing electrical system for construction power shall be coordinated and paid for by the Contractor.

9-40.1.6 Nameplates

- A. Nameplates shall be provided on all electrical devices, including but not limited to motor control equipment, MCC cubicles, control stations, junction boxes, panels, motors, instruments, switches, indicating lights, meters, and all electrical equipment enclosures.
- B. Nameplates shall also be provided on all electrical panel interior equipment, including but not limited to: relays, circuit breakers, power supplies, terminals, contractors, and other devices.
- C. Nameplates shall be made of 1/16" thick machine engraved laminated phenolic having black letters not less than 3/16" high on white background or as shown on the drawings or other sections of the Specifications. Nameplates on the interior of panels shall be White Polyester with printed thermal transfer lettering and permanent pressure sensitive acrylic; TYTON 822 or equal.
- D. All nameplates shall include the equipment name and number (and function, if applicable).
- E. Provide warning nameplates on all panels and equipment that contain multiple power sources. Lettering shall be white on red background.
- F. Nameplates shall be secured to equipment with stainless steel screws/fasteners. Epoxy glue may be used where fasteners are not practical if first approved by the Engineer.

9-40.1.7 Thermal (Temperature) Ratings of Equipment Terminations

- A. This section covers the temperature ratings of all electrical equipment terminations provided under this contract.
- B. All materials shall conform to the National Electrical Code Article 110-14C. Wiring and circuit breakers on this project are designed for 75°C operation above 30 amperes; 60°C for 30 amperes and below.

- C. All products furnished on this project shall have electrical terminations rated for 60°C for ampacities of 30 amperes or less and rated for 75°C for ampacities above 30 amperes.

9-40.1.8 Standards And Codes

- A. Permits, licenses, approvals and other arrangements for work shall be obtained and paid for by the Contractor and included in the bid price.
- B. Electrical work shall be executed in strict accordance with the latest edition of the National Electrical Code and local ordinances and regulations.
- C. All electrical equipment, materials, construction methods, tests and definitions shall be in strict conformity with the established standards of the following in their latest adopted revision:
 - 1. Underwriters' Laboratories, Inc. (UL)
 - 2. National Electrical Manufacturers Association (NEMA)
 - 3. Canadian Standards Association (CSA)
 - 4. Electrical Testing Laboratories (ETL)
 - 5. Factory Mutual (FM)
- D. All materials and equipment specified herein shall, within the scope of UL Examination Services, be approved by the Underwriter's Laboratories for the purpose for which they are used and shall bear the UL label.
- E. All materials shall be new, free from defects, of current manufacture, and of quality specified or shown. Each type of material shall be of the same manufacturer throughout the work.

9-40.1.9 Contract Documents

- A. The electrical layouts are generally diagrammatic. The location of equipment is approximate unless dimensioned. Exact locations and routing of conduits shall be governed by structural conditions and physical interference and by locations of electrical terminations on equipment.

9-40.1.10 Reference Documents

- A. The Contractor shall refer to the drawings, project data and shop drawings of other trades for additional details, which affect the proper installation of the work.. Diagrams and symbols showing electrical connections are diagrammatic

only, and so do not necessarily show the exact physical arrangement of the equipment.

9-40.1.11 Site Familiarization

- A. Before submitting a bid, the Electrical Contractor shall familiarize himself with all features of the site that may affect the execution of his work. The Contractor shall take all field measurements necessary for his work and shall assume full responsibility for their accuracy. The Contractor shall take full responsibility for locating and avoiding all substructures. Any damage to existing equipment shall be repaired or replaced by the Contractor at the Contractor's expense.

9-40.1.12 Electrical Submittals

- A. Electrical project data shall be submitted in accordance with the following:

1. Electrical submittals shall be submitted bound in a three -hole or ring binder, labeled with the project name and Contractor's name and an index sheet showing each product being submitted. Provide with section tabs per the electrical specifications by section and paragraph or equipment name, e.g., provide a minimum of one tab section for each piece of equipment in all of the PART 2 PRODUCT Sections 9-42.2.01 - 2.**. Label each equipment submittal sheet with equipment name and number. Indicate location where each item of equipment submitted will be used on the job. Use equipment numbers when available.
2. Submittals shall include the manufacturer's name, address, trade name, catalog model or number, nameplate data, size, layout dimensions, capacity, project specification and paragraph reference. Include other information necessary to establish contract compliance of each item proposed to furnish.
3. The package of submittals shall be largely complete when first submitted. Long lead items may be submitted separately. Each item shall be clearly marked and provided with adequate sales and technical information to clearly show conformance with all aspects of the specification. Packages not provided as described above or largely incomplete shall be returned to the Contractor without comment.
4. Control panels and control systems submittals may be provided separately, but must be followed in a timely manner as to allow coordinated review. Control submittals shall be provided with a Bill of Materials showing quantity, manufacturer's name, catalog number, and supplier name and phone number.
5. Certify on all submittals that the material being proposed conforms to the contract requirements. In the event of any variance, state specifically which portions vary and request a variance in writing.

6. Certify that all furnished equipment is able to be installed in the allocated spaces by stating on each item:
7. \ "This equipment will be able to be installed in the spaces allocated."
8. Shop Drawings shall be provided on 11" x 17" sheets maximum size, and shall be scaled using standard engineering or architectural scales. Wiring diagrams shall identify circuit terminals, and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment.
9. The Engineer will review the original submittal and one resubmittal on each item. Subsequent submittal reviews shall be conducted at the Contractor's expense; the Contractor shall be billed at the Engineer's current hourly rates.

9-40.1.13 Storage And Installation Environment

- A. All electrical equipment shall be stored in a dry environment free from dust, moisture, sprays or vapors, which may be detrimental to their new condition. After installation of equipment, care shall be taken to protect all equipment from all dust, moisture, paint and other spray, harmful vapors, etc. until final acceptance and certificates of occupancy have been obtained.
- B. Equipment shall not be installed in indoor areas until the area is covered, dry and finished to the point that other work will not create dust, vapors, or moisture. Equipment with integral heaters and fans shall not be installed until power is available at the location, and the heater and fan shall be energized within 6 hours of the equipment being installed.

9-40.1.14 Final Acceptance

- A. Prior to final acceptance the Engineer will perform one or more site observation trips to develop a "punch list" of items deemed incomplete. The Electrical Contractor and System Integrator shall be present while these inspections are taking place and shall be available for opening cabinets and operating and adjusting the system as is necessary for the Engineer to verify all equipment is installed and operates to the requirements of the contract documents.
- B. Prior to the Contractor calling for this observation, the Contractor shall have completed all items of work, including wire markers, nameplates, final tests and final test reports. All equipment shall be checked for proper operation and all signals verified for correct calibration and wiring. Fixtures shall have been cleaned and burned out or defective lamps shall have been replaced.
- C. Final acceptance will not be given until:

1. All work is complete
 2. All punch-lists are checked off and returned to the Engineer
 3. All test reports are received
 4. All O&M manuals are received
 5. All spare parts are received
 6. All instrument test forms are received
 7. All project record drawings are received.
- D. A punch list shall be prepared by the Engineer. Each punchlist item shall be completed by the Contractor and checked off of the list. When all of the items on the list are completed or commented on, the list shall be signed by the Contractor and returned to the Engineer for verification.

9-40.1.15 Project Record Drawings

- A. A set of drawings shall be maintained at the job site (by the Electrical Contractor) showing any deviations in the electrical systems from the original design.
- B. Another complete set of drawings shall be marked up in the office showing the changes made on the field set of drawings. All changes shall be clearly marked in red on the drawings. Drawings shall be submitted to the Engineer at the completion of the project.
- C. A set of electrical drawings marked in red to indicate the routing of conduit runs, shall be submitted to the Engineer for review at the completion of conduit rough-in and prior to cover.

9-40.1.16 Guarantee

- A. The Contractor shall guarantee his work and all components thereof, excluding incandescent and fluorescent lamps for a period of 1 year from date of acceptance of the installation. He shall remedy any defects in workmanship and repair or replace any faulty equipment which shall appear within the guarantee period without additional cost to the Owner.

9-40.1.17 Cleanup

- A. The premises must be kept free of accumulated materials, rubbish and debris at all times. Surplus material, tools and equipment must not be stored at the job

site. At the completion of the job, all equipment and fixtures shall be left clean and in proper condition for their intended use.

- B. Lamps and fluorescent tubes shall be cleaned and defective units replaced at the time of final acceptance.

9-40.1.18 Operation and Maintenance Manuals

- A. The Contractor shall prepare and assemble detailed operation and maintenance manuals in accordance with the project general requirements and other requirements. The manuals shall be bound in a 3-ring binder and tabbed with an index. In general, the O&M manual format shall meet that of the submittal data in Section 9-40.1.12. The manuals shall include, but not be limited to, the following:

1. Catalog data and complete parts list for all equipment and devices
2. All cut sheets of equipment and components
3. Preventative maintenance procedures
4. Trouble-shooting
5. Calibration
6. Testing
7. Replacement of components
8. Automatic mode operation
9. Manual mode operation
10. System schematics/shop drawings and record drawings
11. As-built wiring diagrams of cabinet and enclosure contained assemblies
12. As-built wiring diagrams of overall system
13. Listing of recommended spare parts
14. Listing of recommended maintenance tools and equipment.

9-40.1.19 Training

- A. Training shall be provided per the specific requirements in other sections of these specifications. In addition to training required in other sections of the specifications, the Contractor shall conduct specifically organized training sessions in the overall operation and maintenance of the electrical system for personnel employed by the Owner. The training sessions shall be conducted to educate and train the personnel in operations and maintenance of all components of the electrical system outside the training requirements in the other Sections. Training shall include, but not be limited to, the following:
1. Preventative maintenance procedures
 2. Trouble-shooting
 3. Calibration
 4. Testing
 5. Replacement of components
 6. Equipment operation
- B. At least two (2) training sessions, each at least two (2) hours in duration, shall be conducted at the facility after start-up of the system. The Contractor shall prepare and assemble specific instruction materials for each training session and shall supply such materials to the Owner at least 2 weeks prior to the time of the training.

9.41 OVERCURRENT PROTECTIVE DEVICES

9-41.1.1 Description of Work

- A. This section covers the furnishing and installation of all fuses and circuit breakers used in this project.

9-41.1.2 Standards and Codes

- A. All materials and equipment specified herein shall, within the scope of UL Examination Services, be approved by the Underwriter's Laboratories for the purpose for which they are used and shall bear the UL label.
- B. All materials and equipment specified herein shall conform with all applicable NEMA, ANSI and IEEE standards.
- C. All materials and equipment specified herein and their installation methods shall conform to the latest published version of the National Electric Code (N.E.C.).

- D. All materials shall conform to the National Electrical Code Article 110-14C. Wiring and circuit breakers on this project are designed for 75°C operation above 30 amperes: 65°C for 30 amperes and below.

9-41.1.3 Submittals

- A. In accordance to the submittal requirements in Section 9.40.1.12, submit catalog data showing material information and conformance with specifications. The intended use of each item shall be indicated.

9-41.2.1 Fuses

- A. Fuses shall be of the type and amperage indicated on the drawings. The voltage rating shall be appropriate for the application indicated. The fuse types indicated on the drawings imply a certain set of fuse characteristics. No substitutions of fuse types will be allowed without written approval from the Engineer.
- B. All fuses used on the project shall be provided with "blown fuse" indicators.
- C. Where fuses in motor circuits are indicated but not sized, provide Manufacturer's recommended fuse size based on actual motor installed.
- D. Provide in-line or integrally-mounted fuse clips on control power or low-voltage transformer.
- E. Provide fuse puller or pullers for fuse sizes used.
- F. Provide surface mounted cabinet sized to store required spare fuses at location coordinated with Owners Representative.
- G. Provide a minimum of two spare fuses for each fuse used.
- H. Acceptable Manufacturers:
1. BUSSMAN
 2. GOULD SHAWMUT
 3. LITTLEFUSE
 4. RELIANCE

9-41.2.2 Molded Case Circuit Breakers

- A. Molded case circuit breakers shall be quick-make and quick-break type. They shall have wiping type contacts. Each shall be provided with arc chutes and individual trip mechanisms on each pole consisting of both thermal and magnetic trip elements. Two and three pole breakers shall be common trip. All breakers shall be calibrated for operation in an ambient temperature of 40°C. Molded case circuit breakers shall be trip-free. Each breaker shall have trip indication independent of the ON or OFF positions.
- B. Breakers shall have lugs UL listed for both copper and aluminum.
- C. Circuit breakers shall be capable of accepting the cable shown on the drawings. Circuit breakers not capable of accepting the cable shown shall not be acceptable.
- D. Breakers shall have the interrupting rating and trip rating indicated on the drawings.

9-41.2.3 Uses

- A. Breakers covered under this specification may be installed in switchboards, panelboards, motor control centers, combination motor starters and individual enclosures.

9-41.2.4 Enclosures

- A. Unless otherwise shown on the drawings; enclosures for protective devices shall be NEMA rated for the environment in which they are installed. In general, devices installed indoors shall be in NEMA 12 enclosures, devices installed outdoors shall be in NEMA 4X enclosures.

9-41.3.1 Installation

- A. Fuses and circuit breakers shall be installed in their respective enclosures and locations in such a manner as to ensure tight connections to preclude arcing and overheating.

9.42 SERVICE AND METERING

9-42.1.1 Description of Work

- A. Work consists of installation of new 100 amp 230/115V, 1Ø underground service, service transfer and service entrance equipment.

9-42.1.2 Scheduling work with the Utility Company

- A. The Contractor shall be fully and completely responsible for all scheduling and coordination with the utility company. The Contractor shall coordinate and schedule power outages, power service for operation and construction, and power service as may be required by the facility prior to Certificate of Occupancy.
- B. The Contractor shall make all necessary applications for service with the utility, and shall notify the Owner in writing of any obligations that the Owner must fulfill for service to be started, installed, or modified.

9-42.1.3 Contractor/Utility Interface Responsibilities

- A. The electrical utility providing service to these facilities is Tacoma Public Utilities (TPU).
- B. During design, contact was made with Terry Caillier at TPU at (253) 502-8436. The division of responsibilities stated below has been determined by coordination with the utility. The Contractor shall comply with all utility company standards and requirements.
- C. All utility company charges for and related to the final permanent service to the facility will be paid by the Owner, directly to the utility company and shall not be included in the Contractors bid price.

- D. Any and all modifications to the service or power system at the facility shall be paid for by the Contractor.
- E. The Contractor shall notify the Owner in writing of any obligations or forms that the owner is responsible to provide for service.

9.42.1.3.2 The Contractor Shall

- A. Provide trenching, backfill and borrow material for the primary extension.
- B. Provide trenching, backfill and borrow material for the secondary service.
- C. Provide the transformer vault.
- D. Provide underground secondary conduit and wiring, from the utility company transformer to the metering. Provide sufficient conductor to reach and connect to the transformer secondary terminals.
- E. Provide the meter enclosure.

9.42.1.3.2 The Utility Company Will

- A. Provide and install primary conductors in the contractor excavated areas.
- B. Provide new service transformer and terminate primary and secondary conductors.
- C. Provide and install meter in Contractor supplied enclosure.

9.42.1.4 Quality Assurance

- A. Comply with all serving utility company standards and requirements.

9-42.1.5 Standards and Codes

- A. Work involving service installation shall be done in accordance with the serving utility's standards and the National Electric Code.
- B. Service equipment shall be listed and labeled by UL as "suitable for use as service equipment".

9-42.1.6 Submittals

- A. In conformance with the submittal requirements of Section 9-40, submit catalog data showing material information and conformance with specifications on the following:
- B. Prior to submittal to the Engineer, the Contractor shall submit all equipment and construction details (such as size, mounting height, location of equipment, etc.) to the serving utility for verification of compliance to the utility's requirements.
 - 1. Meter Enclosure
 - 2. Service Entrance Breaker
 - 3. Surge Arrestors

9-42.2.1 Meter Enclosure

- A. Meter enclosure shall be Circle AW and as required to meet the requirements of the serving utility. Installation shall be in vandal proof NEMA 3R enclosure with a lockable hinged door.
- B. Contractor shall coordinate with utility company on type of metering required and shall provide all labor and material necessary to meet utility co. requirements.

9.42.2.2 Service Entrance Breaker

- A. Service entrance shall be outdoor NEMA 3R construction and shall contain the circuit breaker, neutral and ground buses. Service equipment shall meet the requirements of the serving utility and shall be suitable for use as service equipment.

9.42.2.3 Surge Arrestors

- A. Provide Surge arrestors , with indicators, where shown on the one-line diagrams to protect against overvoltage transients (JOSLYN J9200 series with protective capacitor GE model 9L18 or equal). Select proper components for the application as shown on the drawings.

9.42.3.1 Ground Electrode System

- A. The grounded conductor and ground bus shall be connected to the grounding electrode.
- B. system, via the grounding electrode conductor as indicated on system one-line diagram.
- C. The system shall be as indicated in Article 250-81 of the National Electrical Code.

9.42.3.2 Underground Secondary Service

- A. Install in accordance with the Plan and utility company requirements.

9.42.3.3 Utility Requirement Verification

- A. The Contractor shall coordinate and submit all equipment, materials, etc. related to the utility work to the serving utility to verify conformance to the Utility's requirements for service. The Contractor shall also submit any plans for the installation of the primary and secondary service for approval by the Utility prior to excavation. Any discrepancy between the Utility requirements and the Contract documents shall be brought to the immediate attention of the Engineer.

9.43 PANEL BOARDS

9-43.1.1 Description of Work

- A. This section covers the furnishing and installation of all panelboard equipment complete.

9-43.1.2 Standards and Codes

- A. All materials and equipment specified herein shall, within the scope of UL Examination Services, be approved by the Underwriter's Laboratories for the purpose for which they are used and shall bear the UL label.
- B. All materials and equipment specified herein shall conform with all applicable NEMA, ANSI and IEEE standards.
- C. All materials and equipment specified herein and their installation methods shall conform to the latest published version of the National Electric Code (N.E.C.).

9-43.1.3 Submittals

- A. Submit catalog data showing material information and conformance with specifications. The intended use of each item shall be indicated.

9-43.2.1 Panelboard Type

- A. Panelboards shall be rated at proper voltage and current for intended use with bus bars of aluminum. Panels shall have phases, voltage and current ratings as shown on the drawings. Panels shall have 100 percent neutral, with equipment ground bar, unless noted otherwise. Panelboards shall be dead front.
- B. Panels shall have as a minimum the number of circuits shown on the panel schedules on the drawings.

9-43.2.2 Circuit Breakers

- A. The following interrupting capacity shall be considered minimum. Other ratings shall be as specified on the drawings.
- B. 240V and 208Y/120V Panelboards 10,000 AIC symmetrical
- C. Mount breakers in all panelboards so that breaker handles operate in a horizontal plane. Bolt-type only. Provide common trip on all multiple pole breakers.
- D. Where noted, provide spare breakers, complete for future connection of wiring circuits. Where "Space Only" is indicated for breakers, provide all bussing and breaker mounting hardware in the panelboard; provide steel knockouts in dead front metal closure of unused part of panel. If any steel knockouts are removed, provide breakers in such spaces or approved cover plates. Open spaces are not permitted.

9-43.2.3 Cabinet for Each Panelboard

- A. Cabinet shall be flush or surfaced as indicated, with tight closing doors without play when latched. Where two cabinets are located adjacent to each other in finished areas, provide matching trim of the same height.
- B. Provide cabinets of sufficient dimensions to allow for future expansion and addition of circuit breakers within the panelboards as indicated on drawings.
- C. Provide lock for each cabinet door. All electrical distribution equipment locks shall be keyed identically.
- D. Fasten panelboard with machine screws with oval countersunk heads, finish hardware quality, with escutcheons or approved trim clamps. Clamps accessible only when dead front door is open are acceptable. Surface mounted panelboards with fronts greater than 48 inches vertical dimension shall have trim hinged at right side in addition to hinged door over dead front.
- E. Provide factory standard lacquer or enamel finish, ASA #49 gray.

9-43.2.4 System of Numbering and Bus Arrangement

- A. Shall be as shown on the Panel Schedules on the drawings.
- B. Provide a type written circuit directory card for each panelboard with the load name, number, location and kVA.

9-43.2.5 Panelboard Nameplate

- A. Provide engraved (color layer - engraved through outer layer) plastic name plate with 1/2 inch high characters for panel identification (for panel name); attached with stainless steel screws to each panelboard front. Emergency system - white on red; Normal system - black letters on white. Include voltage, phase and wire (i.e., 208Y/120V, 3 phase, 4 wire) in 3/8 inch characters.

9-43.3.1 Mounting

- A. Secure in place with top of cabinet at 6' - 6", unless otherwise noted. Top of cabinet and trim shall be level.

9-43.3.2 Circuit Index

- A. For each branch circuit panelboard provide neatly type written, as-built information for each panelboard by circuit with its proper load designation. Mount the panelboard circuit directory inside the door of each panelboard in a clear plastic sleeve. Provide one spare blank card for each card used.

9-43.3.3 Dead Front Closures

- A. Close all openings in dead front with closures manufactured for the purpose or install spare breakers.

9.44 ALARM PANEL & STARTER

9-44.1.1 Description of Work

- A. Work and materials specified in this section include the telemetry equipment for monitoring the pumps and tank level in the vaults and provide the starter for the temporary pump.

9-44.1.2 Control System Integrator

- A. The Control System Integrator shall be solely and completely responsible for the final design and assembly of the entire control system and the power and control panel. The system shall be designed to provide the control capabilities and functions indicated and implied by the plans and these specifications and to provide trouble-free operation with minimum maintenance. The system shall readily enable manual operation of any and all functions in the event of failure of any one component.
- B. The Control System Integrator shall be selected by the Contractor from the following acceptable companies:
 - 1. Custom Controls Corporation – Fife, Washington
 - 2. Superior Custom Controls - Seattle Washington

9-44.1.3 Responsibility of Contractor & Control System Integrator

- A. The manufacturer of the power and control panel shall be fully and completely responsible for the design and assembly of the system as specified herein and shall be enjoined by the Contractor as a subcontractor. The assignment of specific responsibilities herein to the manufacturer shall not, in any way and under any conditions, diminish or usurp the Contractor's full and complete responsibility for all work performed and all materials installed under the contract. The contract between the Contractor and the manufacturer shall specifically require that the manufacturer conform to and meet all requirements specified herein.

9-44.1.4 Standards and Codes

- A. All equipment and materials shall conform to the latest revised editions of applicable standards published by the following organizations:
 - 1. American National Standards Institute (ANSI)
 - 2. Institute of Electrical and Electronic Engineers (IEEE)
 - 3. National Electrical Manufacturers Association (NEMA)
 - 4. Underwriters' Laboratories (U/L)
 - 5. Instrument Society of America (ISA)
 - 6. National Fire Protection Association (NFPA 20)
- B. All electrical equipment and materials, and the design, construction, installation, and application thereof shall comply with all applicable provisions of the National

Electrical Code (NEC), the Occupational Safety and Health Act (OSHA), and any applicable federal, state, and local ordinances, rules and regulations.

- C. All materials and equipment specified herein shall, within the scope of UL examination services, be approved by the Underwriter's Laboratories for the purpose for which they are used and shall bear the UL label.
- D. All control panels shall bear a label by an approved testing authority for the completed assembled panel.

9-44.1.5 Integration With Telemetry

- A. The manufacturer of the alarm panel shall determine all requirements for the alarm system and shall include in the panel all required devices and equipment for interfacing contact closures.

9-44.1.6 Shop Drawings

- A. The Control System Integrator shall develop all shop drawings required for design, fabrication, assembly and installation of the control system. Shop drawings shall include all drawings required in manufacture of specialized components and for assembly and installation of them. Shop drawings shall be CAD drawn and include the following:
 - 1. System schematic diagrams for the entire control system including but not limited to: all sensors, control panels, motor control center and motor control equipment; with all components and their locations indicated. Wire and terminal numbers shall be included on the schematic diagrams.
 - 2. Technical data sheets for all components with the complete part number of the component clearly designated with all required options.
 - 3. Arrangement drawings of all panel front- and internal-mounted instruments, switches, devices, and equipment indicated. Show all panel mounting details required. Include outer dimensions of all panels on the drawing. Deviations from approved arrangements require resubmittal and approval prior to installation.
 - 4. Arrangement drawings shall be drawn to scale using standard Architectural or Engineering scales.
 - 5. Detailed dimensional drawings of the installation of all sensors (level, pressure, flow, valve position, motion, etc.) and of mounting brackets and other devices required for installation of sensors.
 - 6. Shop drawings shall be provided on sheets no larger than 11" x 17". Shop drawings shall include specific product detail such as rating, size, and number of contacts, etc. Wiring diagrams shall be included for all components in the system including control equipment supplied with mechanical devices.
 - 7. Wiring diagrams shall:
 - a) Have a minimum of one sheet per each motor controller, or subsystem.
 - b) Include wiring diagrams for packaged control panels and other related control equipment supplied with mechanical systems.
 - c) Include instrument loop diagrams.

- d) Include for all motor control wiring diagrams, both the motor power and control wiring in the MCC bucket and other related control wiring for the motor on the same sheet at the end of this section.
- e) Include details of individual PLC input and output cards with card wiring, base, slot, input, output, terminal, and device identification.
- f) Provide wire and terminal numbering.
- 8. For shop drawing packages which include more than 10 sheets provide the drawings in a separate 11" x 17" binder with an index for the drawings at the front.
- B. Installation details shall include the size, number, type and location of interconnecting wiring and conduit, installation of cabinets and enclosures, installation of sensors, instruments, limit switches, and other installation requirements. Shop drawings shall be submitted to the Contractor for review and approval. After approval by the Contractor, copies of all shop drawings shall be submitted to the Engineer.

9-44.1.7 Submittals

- A. In accordance with the requirements of Section 8-40.1.10 and other related sections of this specification, the Control System Integrator shall develop and shall submit to the Engineer, through the Contractor, the following project data:
 - 1. All shop drawings.
 - 2. Descriptive text on wire markers to be used.
 - 3. Cut sheets for all products with a Bill of materials showing quantity, manufacturer, catalog number, and the supplier name and phone number. Relate the bill of materials to the submitted product index.
- B. The Contractor shall review all shop drawings prior to submittal to the Engineer. The Contractor's review shall include:
 - 1. Coordination of wire routing on the wiring diagrams and the raceway system.
 - 2. Equipment shall be checked for layout and size for coordination and verification that equipment will fit within the space designated.
 - 3. Coordinate with panel wire entrances and interior wireways and space (size and location) for field connections.
 - 4. Coordination of equipment mounting and installation.

9-44.1.8 Warranty

- A. In accordance with the requirements of Section 9.40 1.16, the Contractor shall guarantee the control system to be free of defects in design, materials and workmanship for a period of one (1) year following the date of acceptance, by formal action of the Owner, of all work under the contract.
- B. As part of the guarantee, the Contractor and the manufacturer of the power and control panel shall indemnify and hold harmless the Owner, the Engineer and their officers, agents and employees against and from all claims and liability arising from all damage and injury due to defects in the control system.

- C. The Contractor shall cause the manufacturer of the power and control panel to make any and all repairs, replacements, modifications and adjustments within three days of notification. Should the manufacturer fail to begin the work within two days or complete the work within three days, the Owner may proceed to undertake or complete the work. In such event, the Contractor and his surety shall be liable for all costs incurred by the owner.

9-44.1.9 Operation and Maintenance Data

- A. The manufacturer of the power and control panel shall prepare and assemble detailed operation and maintenance manuals in accordance with the requirements of section 9.40 1.12. The manuals shall include, but not limited to the following:
1. Preventative maintenance procedures
 2. Trouble-shooting
 3. Calibration
 4. Testing
 5. Replacement of components
 6. Automatic mode operation
 7. Manual mode operation
 8. System schematics
 9. As-built wiring diagrams
 10. Catalog data and complete parts list for all equipment and control devices
 11. Listing of recommended spare parts
 12. Listing of recommended maintenance tools and equipment

9-44.1.10 Coordination With Motor Control and Other Equipment

- A. The Control System Integrator shall be solely and completely responsible for coordination and integration of control system with the motor control and other related equipment. The Control System Integrator shall communicate directly with the manufacturer(s) and supplier(s) of all related control equipment to determine all intended details of the equipment which may influence or affect the control system. The Control System Integrator shall determine all requirements for and shall cause integration of the control system and all other control equipment into a unified operating system. The Control System Integrator shall define all requirements for all interfacing equipment and shall supply all appurtenances, accessories and all such devices which may be required for proper interfacing as part of the control system.
- B. The Integrator shall be responsible to obtain submittal information on equipment supplied by other disciplines and to integrate them into the control system to form a complete working package as outlined by the contract documents. This includes but is not limited to a pneumatic pump.

9-44.2.1 General

9-44.2.2 Design and Assembly

- A. All equipment and materials utilized in the system shall be the products of reputable, experienced manufacturers with at least five (5) years experience in the manufacture of similar equipment. Similar items in the system shall be the products of the same manufacturer. All equipment shall be of industrial grade and of standard construction, shall be capable of long, reliable, trouble-free service, and shall be specifically intended for control and monitoring of operation of motor-driven pumps and equipment. All equipment shall be of modular design to facilitate interchangeability of parts and to assure ease of servicing. All equipment, where practical, shall be of solid state, integrated circuit design.
- B. The system shall be completely assembled in the shop by the Control System Integrator. All components and equipment shall be prewired to the maximum extent possible.
- C. All components, including both internally and face-mounted instruments and devices, shall be clearly identified with phenolic nameplates of white background with black letters. Nameplates on the interior of panels shall be White Polyester with printed thermal transfer lettering and permanent pressure sensitive acrylic; TYTON 822 or equal.

9-44.2.3 Interconnecting Wiring/terminals

- A. The Control System Integrator shall determine all requirements for field-installed interconnecting wiring between control system components, sensors, pumps and equipment. The Control System Integrator shall determine the number, size, and type of wires and the number, size, type, and location of conduits and wireways.
- B. The wire and conduit shown on the plans shall be considered only as general guidelines for signal and control circuits. The Control System Integrator shall determine all specific requirements and shall confirm or modify the wiring and conduit shown on the plans to conform to such requirements.
- C. All interconnecting wires installed by the manufacturer and installer shall be numbered at each end using custom pre-printed heat shrink sleeve markers. Markers shall be T&B, SHRINK-KON HVM or approved equal. Terminations shall be made using solderless pressure connectors at all terminations. All conductors shall be stranded wire with thermoplastic insulation and shall be cabled to groups and supported so as to prevent breaking and to present an orderly arrangement and neat appearance. All outgoing wiring shall be terminated on a marked terminal strip capable of connection of at least 2 No. 14 wires and all terminal connections shall be numbered consecutively throughout the system.
- D. Provide 5 spare terminals in each enclosure that has terminals or 10% whichever is the greater amount. In addition, provide extra din rail with enough space for 20% more terminals.

- E. For all energized circuits (power and control) powered from the panel and extend outside of the panel provide an individual fused terminal with appropriate fuse and "blown fuse" indicator light for each circuit.
- F. For all energized circuits powered outside of the panel which extend into the panel, provide a disconnecting terminal to isolate each individual circuit with indicator light to show the circuit is energized.
- G. In general all control wiring shall be #14 AWG except PLC I/O wiring between the PLC cards and the terminal strips within the same cabinet shall be #18 AWG.
- H. Provide wire ways as necessary in the enclosure to contain all internal wiring and all field wiring. Size wireways such that there is ample room for the wiring required by this contract. Wireways shall be filled to a maximum of 70% to allow 30% more future wire.
- I. Low voltage DC control and signal conductors shall be bundled separately from alternating current circuits. Separate raceways and wire gutters shall be dedicated for AC and DC wiring, and labeled as such on the shop drawings. Wiring may cross at right angles if necessary. Special caution shall be used for PLC I/O card wiring and field terminations to accommodate the separation of AC and DC circuits. Intrinsically safe wiring shall be physically separated from non intrinsically safe wiring.
- J. All wiring shall be neatly tied in position with nylon cable ties. Instruments with portable cord connections shall be fed through the instrument panel plug strip which shall be located near the top of the panel directly above the instruments. Instrument supply cords shall be the only panel wiring which is not continuously supported and tied.
- K. All wiring and tubing crossing hinges shall be installed in a manner to prevent chafing. Bundles of similar conductors shall be clamped securely to the door and to the panel, and the bundles shall run parallel to the hinge for at least 12 inches. Spiral nylon cable wrap shall be provided in the hinge section of the bundle to fully protect the conductors or tubing against chafing.

9-44.2.4 Motor Starter Units/Contactors

9-44.2.4.1 General

- A. Motor starter units shall be of the combination type with components as indicated on the drawings. Magnetic contactors shall be heavy duty NEMA rated, SQUARE-D type S, ALLEN BRADLEY Bulletin 509, FURNAS INNOVA, CUTLER HAMMER FREEDOM, or equal. All contactors shall be provided with two field convertible auxiliary contacts. An auxiliary switch shall be provided to indicate the circuit breaker is in the "ON" position. Switch shall be open when the circuit breaker is open. Motor starters and associated equipment shall be provided to match the load being served.

9-44.2.4.2 Overload Relays

- A. Thermal overload relays on starters shall be non-ambient compensated bimetallic type or solid state type with selector for either auto or manual reset. Overload Relays shall monitor all energized conductors. A Separate normally open overload contact shall be provided in addition to standard normally closed overload contact. Overload relay shall be provided with a circuit test button which shall simulate an overload trip, trip indication, and reset pushbutton. Overload which trip on phase fail shall automatically reset upon normal power restoration.

9-44.2.4.3 Transient Suppressors

- A. Provide all contactor coils with transient suppressors to limit the high voltage transients produced when power is removed from the coil (CUTLER HAMMER - C320AS1 or equal).

9-44.2.4.4 Double Enclosures for Outdoor Areas

- A. The exterior panel shall be NEMA 3R made of aluminum (.125" thick minimum) with double flanged door frame on all four sides. All exterior seams shall be continuously welded or sealed. Provide enclosure with louver vents, vent fan and thermostat. Exterior enclosure shall be Hennessy Products, Inc. freestanding enclosure or equal with minimum size as shown on drawings.
- B. The interior enclosure shall be NEMA 12 aluminum construction equal to Hennessy Products, Inc. standards and quality of manufacture. Enclosure sizes shall be a minimum of that shown on the drawings. Provide inner enclosure with vents, heater, and thermostat. Provide outer enclosure with vents, fan and thermostat.

9-44.2.4.5 Enclosure Door Latches

- A. Door latches shall be fast operating type 3-point latch door handle; or where a 3-point latch will not meet rating requirements use fast operating clamp assemblies (maximum of two latches per enclosure). Hoffman Bulletin A-80. The latch handle shall operate toward the center of the panel to open the door, and be pointing down when closed and locked. All outdoor cabinets shall be lockable.

9-44.2.4.6 Wireways

- A. Provide molded plastic wireways, slotted for wire connections for all wiring in the panels. They shall be complete with covers. Wireways shall be manufactured by Panduit or Taylor.

9-44.2.4.7 Terminals

- A. Provide terminals for all wire connections to field wiring and internal power distribution. Analog loops that are 24 VDC powered shall have a knife switch to disable the loop if necessary. Connections shall have box type lugs capable of terminating 2 #14 AWG stranded wires. Terminals shall be strip mounted as manufactured by Entrelec or Phoenix Contact.
- B. Fuse terminal blocks shall be hinged disconnect level type with "blown fuse" indicators. PHOENIX CONTACT UK 5 series or equal.
- C. Disconnecting terminal blocks shall be knife type with light indicator PHOENIX CONTACT type MTK or equal.
- D. Provide 1 spare, or 3% whichever is the greater amount, spare (non installed) replacement terminals for each type used.

9-44.2.4.8 Strip Heater

- A. Provide a 100 watt (or as shown on the plans) resistance heater with 120 VAC line thermostat in each control enclosure located outdoors or in moist environments. The thermostat shall be adjustable between 50°F. and 80°F.

9-44.2.5 Operator Interface Devices

9-44.2.5.1 General

- A. All operator interface devices mounted on the panel front shall be rated for the environment in which they will be located. In general, devices mounted on indoor panels shall be NEMA 13 rated. Operator devices mounted outdoors, or in wet or corrosive environments shall be NEMA 4X rated.

9-44.2.5.2 Elapsed Time Meters

- A. Elapsed Time Meters (ETM) or run time (RTM) on control panels shall be 1-1/2" x 3/4" nominal size, case type for flush panel mounting. The meter face shall be of the style that most closely resembles the indicating instruments and shall have black trim with white or aluminized face. The meters shall have a 6-digit non-reset register with the last digit indicating tenths of an hour (Veeder-Root or equal).

9-44.2.5.3 Selector Switches

- A. Selector switches shall be NEMA 13, or NEMA 4X as required by mounting location. Selector switches shall be 2, 3, or 4 position as required by the application. Selector switches installed outdoors shall have knob lever operator handle. Selector switches installed indoors shall have standard knob operator. Units shall be heavy duty type, Allen-Bradley 800H or 800T, G.E. Series CR104P or equal.

9-44.2.5.4 Outdoor Alarm Beacon

- A. The outdoor alarm beacon shall be 120V powered flashing high intensity strobe light with double fresnel lens. Beacon shall have no moving parts, transistorized power supply and xenon flash tube flashing a 360 degree beam through a shatter resistant Lexan optic lens. Triggering and timing circuits shall be integral parts of the power supply (Edwards 57-R-AY or approved equal). Provide interposing relay for interface with the PLC.

9-44.2.6 Relays

9-44.2.6.1 Relays for General Purpose

- A. Relays for general purpose use shall have, 10 Amp contacts with the appropriate coil voltage for the application. All relays shall have an integral indicating light to show if there is coil voltage present. They shall have an 8-pin/blade base and matching socket. Units shall be Allen-Bradley 700 type HA, HB, Idec RH Series, or equal. Appropriate relay shall be selected based on application from the control wiring diagrams.

9-44.2.6.2 Time Delay Relays

- A. Time delay relays shall be multi-function, multi-range with plug-in base ,pin style terminations, timing and timed out LED indicators, and calibrated scales. Relays shall have minimum 0.5 seconds to 60 minutes, 8 selectable timing ranges, 5 amp contacts. Select coil voltage for the application. Minimum accuracy requirements (plus or minus) shall be as follows: 1) Repeat accuracy 1/2% 2) Timing change over full voltage range 1/2% change over full temperature range 2% 3) Scale tolerance 5%. Allen-Bradley Bulletin 700 type HR series; IDEC, GT3A or equal. Appropriate relay shall be selected based on application from the control wiring diagrams.

9.44.2.7 Control Sensors

9-44.2.7.1 Drywell Liquid Level Switches (Flood Switch)

- A. Provide drywell liquid level switch, hermetically sealed, magnetically actuated, snap action, 15W, 120V SPST, N.C. (dry). TRANSAMERICA DELAVAL - GEMS LS-1900 or 1950 chosen for the environment or approved equal.

9.44.2.8 Alarm Panel (RTU)

- A. The equipment shall be a remote telemetry unit suitable for communication over a twisted shielded pair. It shall operate at both 12 Vdc and with power at 120 Vac. Provide with 12 Vdc battery for 36 hours of operation (non-alarming). It shall have 8 digital inputs and 4 outputs plus a communications monitor. It shall be

equipped with a modem for bi-directional communications over a dedicated line. Unit shall be Consolidated Electric E687, no equal.

9-44.3.1 Operating Device Location

- A. Operating devices shall be mounted no higher than 6' - 6" and no lower than 4' - 0" above finished floor when panel is installed unless otherwise approved by the Engineer. Indicating devices may be installed higher than 6' - 6".

9-44.3.2 Installation

- A. The power and control panel shall be installed by the Contractor or, at the option of the Contractor, by the manufacturer of the panel in accordance with the installation drawings and instructions prepared by the manufacturer. Installation shall be performed by workers who are skilled and experienced in the installation of electrical instrumentation and control systems.
- B. Installation shall include all elements and components of the panel and all interconnecting wiring between all equipment, components, and sensors. All wiring between cabinets, sensors and equipment shall be labeled at both ends for ease of servicing. All terminations shall be made with solderless pressure connectors. All wiring shall be in accordance with the plans. Intrinsically safe wiring shall be barriered per NEC requirements.
- C. Connection between the power and control panel and the existing telemetry equipment shall be included as indicated on the drawings and will be the responsibility of the Contractor.

9-44.3.3 Inspection and Verification of Installation

- A. After completion of the installation of the panel, the manufacturer shall inspect the installation and verify that all components and wiring are correctly installed. The manufacturer shall determine the exact scope and nature of work required to correct deficiencies and errors in the work and shall supervise the performance of such work.

9-44.3.4 Calibration and Start-up

- A. All components of the panel shall be calibrated by the manufacturer after completion of installation. Each component shall be adjusted to be within the required range and for the specific application. Components that cannot be properly calibrated or that are found to exceed the specified range or accuracy shall be removed and replaced.
- B. After completion of construction of the pump station, the panel shall be placed into operation by the manufacturer. Installation shall be performed by workers who are skilled and experienced in the installation of electrical instrumentation and control systems.

- C. The manufacturer of the power control panel shall be solely and completely responsible for all maintenance of the system from time of start-up to the date of acceptance, by formal action of the Owner, of all work under the contract. The manufacturer shall correct all deficiencies and defects and make any and all repairs, replacements, modifications, and adjustments as malfunctions or failures occur. The manufacturer shall perform all such work required or considered to be required by the owner to cause and maintain proper operation of the system and to properly maintain the systems.
- D. The Contractor and the manufacturer of the power control panel shall anticipate that the owner may delay acceptance of all work under the contract if, in the judgment of the owner, malfunctions or failures in operation of the panel occur after start-up. Both the Contractor and the manufacturer shall not be entitled to an extension of time or to any claim for damages because of hindrances, delays or complications caused by or resulting from delay by the owner in accepting the work because of malfunctions or failures in operation of the panel.

9-44.3.5 Operation and Maintenance Training

- A. The manufacturer of the power control panel shall conduct specifically organized training sessions in operation and maintenance of the panel for personnel employed by the Owner. The training sessions shall be conducted to educate and train the personnel in maintenance and operation of all components of the panel. Training shall include, but not be limited to, the following:
 - 1. Preventative maintenance procedures
 - 2. Trouble-shooting
 - 3. Calibration
 - 4. Testing
 - 5. Replacement of components
 - 6. Automatic mode operation
 - 7. Manual mode operation
- B. Two (2) separate training sessions, each at least two (2) hours in duration, shall be conducted at the pumpstation (after start-up of the system) concerning instruction and operation of the power and control panel, and all associated electrical equipment and devices. The manufacturer shall prepare and assemble specific instruction materials for each training session and shall supply such materials to the owner at least four (4) weeks prior to the time of the training.